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THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

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VOL. LIII.

1902-1903.

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NORTH OF ENGLAND INSTITUTE

OF

MINING AND MECHANICAL ENGINEERS.

THE INSTITUTION OF MINING ENGINEERS.

THIRTEENTH ANNUAL GENERAL MEETING,
HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,
SEPTEMBER 17TH, 1902.

MR. JAMES S. DIXON, RETIRING-PRESIDENT, IN THE CHAIR.

ELECTION OF OFFICERS, 1902-1903.

The SECRETARY announced the election of officers for the ensuing year by the Council as follows:—

PRESIDENT:
SIR. LINDSAY WOOD, BART.

VICE-PRESIDENTS:

Mr. HENRY AITKEN.	MR. M. DEACON.	MR. GEORGE MAY.
SIR LOWTHIAN BELL, BART.	MR. J. T. FORGIE.	MR. H. B. NASH.
MR. G. E. COKE.	MR. JOHN GERRARD.	MR J. B. SIMPSON.
MR. JOHN DAGLISH.	MR. A. MAYON HENSHAW.	MR. J. G. WEEKS.
	MR. R. S. WILLIAMSON.	

AUDITORS:
MESSRS. JOHN G. BENSON AND SON, Newcastle-upon-Tyne.

TREASURERS:
MESSRS. LAMBTON AND COMPANY, The Bank, Newcastle-upon-Tyne.

The SECRETARY read the Annual Report of the Council as follows:—

THE INSTITUTION OF MINING ENGINEERS.

THIRTEENTH ANNUAL REPORT OF THE COUNCIL.

The six federated societies constituting The Institution of Mining Engineers are the same as last year, namely the Midland Counties Institution of Engineers; the Midland Institute of Mining, Civil and Mechanical Engineers; the Mining Institute of Scotland: the North of England Institute of Mining and Mechanical Engineers; the North Staffordshire Institute of Mining and Mechanical Engineers; and the South Staffordshire and East Worcestershire Institute of Mining Engineers.

The following table exhibits the progress of the membership since the formation of the Institution in 1889:—

Year ending July 31st.	No. of Members.	No. of Non-federated.	Totals.
1890	1,189	50	1,239
1891	1,187	9	1,196
1892	1,415	19	1,434
1893	1,533	19	1,552
1894	2,068	123	2,191
1895	2,210	109	2,319
1896	2,301	81	2,382
1897	2,447	60	2,507
1898	2,462	47	2,509
1899	2,445	41	2,486
1900	2,447	35	2,482
1901	2,524	30	2,554
1902	2,571	30	2,601

Messrs. E. Harzé, W. H. Pickering and Fred. A. Grey have been elected Honorary Members of the Institution.

The Institution took charge of Section VI.—Mining and Metallurgy—of the International Engineering Congress held at Glasgow in September, 1901. The members are to be congratulated upon the excellent papers communicated at this meeting, and at that held in London in May, 1902. The thanks of the Institution have been sent to the gentlemen who kindly opened their collieries and works to the members attending these meetings.

Prizes have been awarded to the writers of the following papers, which are printed in the *Transactions* (vols. xviii. and xix.):

"Probable Duration of the Scottish Coal-fields." By Mr. R. W. Dron.
"Notes upon Ancient and Modern Surveying, and Surveying Instruments, Books, Tables, etc." By Mr. H. D. Hoskold.
"The Rating of Coal-mines." By Mr. G. Humphreys-Davies.
"Subsidences in and around the Town of Northwich, Cheshire." By Mr. Thomas Ward.

Addresses have been delivered during the year by Sir William Thomas Lewis, Bart., and Mr. James S. Dixon, presidents of The Institution of Mining Engineers; by Mr. G. E. Coke, president of The Midland Counties Institution of Engineers; by Mr. Henry Aitken, president of The Mining Institute of Scotland; by Prof. Charles Lapworth, president of the South Staffordshire and East Worcestershire Institute of Mining Engineers; and by Mr. James Mansergh, president of the International Engineering Congress, Glasgow, 1901.

The high standard of the papers published in the *Transactions* has been maintained, and the Council trust that papers will be contributed as liberally as heretofore.

The papers on geology include the following:—

"Slips in a Sandbank." By Mr. James Barrowman.
"The Carboniferous Limestone Coal-fields of West Lothian." By Mr. Henry M. Cadell.
"The Oilshale-fields of the Lothians." By Mr. Henry M. Cadell.
"The Mining, Concentration and Analysis of Corundum in Ontario, Canada." By Dr. W. L. Goodwin.
"Some Silver-bearing Veins of Mexico." By Mr. Edward Halse.
"The Coal-field of Northern Belgium." By Mr. É. Harzé.
"The Sequence of the Carboniferous Rocks in North Staffordshire." By Dr. Wheelton Hind.
"Lead- and Zinc-deposits of the Mississippi Valley, U.S.A." By Messrs. C. R. Van Hise and H. Foster Bain.
"Deposits of Hydroborate of Lime: Its Exploitation and Refination." By Mr. Carlos A. Lynes Hoskold.
"The Dysart, Wemyss and Leven Coal-field, Fifeshire." By Mr. Richard Kirkby.
"Note on a Mineral Vein in Wearmouth Colliery." By Prof. Henry Louis.
"Mineral Resources of the Province of Quebec, Canada." By Mr. J. Obalski, H.M. Inspector of Mines.
"The Rand Conglomerates, Transvaal." By Mr. Hugh Pearson.
"The Belvoir Iron-ore." By Mr. R. F. Percy.
"The Coal-fields of New Brunswick, Canada." By Mr. Henry S. Poole.
"The Tarquah Gold-field, Gold Coast, West Africa." By Mr. A. R. Sawyer.
"The Tarkwa Gold-field, West Africa." By Mr. A. R. Sawyer.
"The Buffelsdoorn and Adjacent Districts of the Northern Klerksdorp Gold-fields, Transvaal." By Mr. William Smith.
"The Carboniferous Limestone Quarries of Weardale." By Mr. A. L. Steavenson.

"Recent Work in the Correlation of the Measures of the Pottery Coal-field of North Staffordshire, with Suggestions for further Development." By Mr. John T. Stobbs.

Mining engineering has been discussed in the following papers:—

"The Working of Contiguous, or nearly Contiguous, Seams of Coal." By Mr Thomas Arnott.

"Working Coal under the River Hunter, the Pacific Ocean and its Tidal Waters, near Newcastle, in the State of New South Wales." By Mr. A. A. Atkinson, H.M. Inspector of Mines.

"Description of Underground Haulage at Mossblown Colliery, Ayrshire." By Mr. James Baird.

"What is the least possible Waste in Working Coal?" By Mr. James Barrowman.

"Unwatering and Fitting a Lanarkshire Colliery with Modern Appliances." By Mr. Robert Broom.

"The Occurrence, Mode of Working, and Treatment of the Ironstones found in the North Staffordshire Coal-field." By Mr. John Cadman.

"A Method of Working the Thick Coal-seam in two Sections." By Mr. William Charlton.

"Coal-mining in India." By Mr. R. W. Clarke.

"Sinking by Freezing." By Mr. A. Gobert.

"The Mining, Concentration and Analysis of Corundum in Ontario, Canada." By Dr. W. L. Goodwin.

"Mining and Treatment of Copper-ore at the Wallaroo and Moonta Mines, South Australia." By Mr. H. Lipson Hancock.

"The Working of Contiguous, or nearly Contiguous, Seams of Coal." By Mr. John Hogg.

"The Dysart, Wemyss and Leven Coal-field, Fifeshire." By Mr. Richard Kirkby.

"The Working of Contiguous, or nearly Contiguous, Seams of Coal." By Mr. Thomas Moodie.

"Boring in Japan." By Mr. F. J. Norman.

"The Re-opening of Hartley Colliery." By Mr. R. E. Ornsby.

"Gold-dredging in Otago, New Zealand." By Mr. F. W. Payne.

"The Belvoir Iron-ore." By Mr. R. F. Percy.

"Chinese Mines and Miners." By Mr. Alexander Reid.

"The Tarquah Gold-field, Gold Coast, West Africa" By Mr. A. R. Sawyer.

"The Tarkwa Gold-field, West Africa." By Mr. A. R. Sawyer.

"The Bu'elsdoorn and Adjacent Districts of the Northern Klerksdorp Gold-fields, Transvaal" By Mr. William Smith.

"The Carboniferous Limestone Quarries of Weardale." By Mr. A. L. Steavenson.

"Auriferous Gravels and Hydraulic Mining." By Mr. William S. Welton.

"Tapping Drowned Workings at Wheatley Hill Colliery." By Mr. W. B. Wilson, Jun.

Mechanical engineering has been the subject of the following papers:—

"A Method of Socketing a Winding-rope, and its Attachment to a Cage without the Use of Ordinary Chains." By Mr. W. C. Blackett.

"The B.C.B. Instantaneous Either-side Brake for Railway Wagons and Similar Vehicles." By Mr. Edward Brown.

"Newcomen Engines." By Mr. M. Walton Brown.

"An Instrument for the Automatic Record of Winding Operations." By Mr. Walter Newton Drew.

"Fitting a New Drum-shaft to a Winding-engine, Florence Colliery, Longton." By Mr. C. V. Gould.

"Some Experiences and Results derived from the Use of highly Superheated Steam in Engines." By Mr. R. Lenke.

"Changing Headgears at Pleasley Colliery." By Mr. G. A. Longden.

"A Regenerative Steam-accumulator, and its Application for Using Exhaust-steam." By Prof. A. Rateau.

The following papers have been contributed on mine-ventilation and safety-appliances:—

"An Apparatus for Lighting Miners' Safety or other Enclosed Lamps by Electric Current." By Mr. Edward Brown.

"Experiments on an Auxiliary Ventilating Fan." By Mr. M. Walton Brown.

"Experimental Gallery for Testing Life-saving Apparatus." By Mr. W. E. Garforth.

"A New Diagram of the Work of Mine-ventilation." By Mr. H. W. G. Halbaum.

"Apparatus for Closing the Top of the Upcast-shaft at Woodhorn Colliery." By Mr. C. Liddell.

"Remarks on Mr. M. Walton Brown's Report on 'Mechanical Ventilators.'" By Prof. A. Rateau.

Mine-surveying and instruments have been treated of in the following papers:—

"A Traversing Stand for a Theodolite."

"The Grubb Sight for Surveying-instruments." By Sir Howard Grubb and Mr. Henry Davis.

"A New Civil and Mining Engineers' Transit-theodolite for Connecting Underground Workings to the Surface, *vice-versâ*, and for General Surveying." By Mr. H. D. Hoskold.

"Standardization of Surveyors' Chains." By Prof. Henry Louis.

"Mine-surveying Instruments." By Mr. Dunbar D. Scott.

"The Connection of Underground and Surface Surveys." By Mr. G. R. Thompson.

The following papers have been written on metallurgy, etc.:—

"A Native Lead-smelting Furnace, Mexico." By Mr. A. H. Bromly.

"The Occurrence, Mode of Working, and Treatment of the Ironstones found in the North Staffordshire Coal-field." By Mr. John Cadman.

"The Imperfect Pulverization of Rocks by means of Stamping, and Suggestions for its Improvement." By Mr. E. D. Chester.

"Crucible-assaying of Gold-ores." By Mr. Hamilton C. Dickson.
"The Mining, Concentration and Analysis of Corundum in Ontario, Canada." By Dr. W. L. Goodwin.
"Mining and Treatment of Copper-ore at the Wallaroo and Moonta Mines, South Australia." By Mr. H. Lipson Hancock.
"Deposits of Hydroborate of Lime: Its Exploitation and Refination." By Mr. Carlos A. Lynes Hoskold.
"Treatment of Low-grade Copper-ores in Australia." By Mr. J. J. Muir.

The application of electricity has been discussed in the following papers:—

"An Apparatus for Lighting Miners' Safety or other Enclosed Lamps by Electric Current." By Mr. Edward Brown.
"The Economy of Electricity as a Motive Power on Railways at present driven by Steam." By Prof. C. A. Carus-Wilson.
"Mechanical Undercutting in Cape Colony." By Mr. John Colley.
"Electric Traction on Roads and Mineral Railways." By Mr. W. R. Cooper.
"Electric Pumping-plant at South Durham Colliery." By Mr. Fenwick Darling.
"The Practical Results obtained on Changing the Motive Power of an Underground Pump from Steam to Electricity." By Mr. Hugh P. Swann.
"Sparkless Electric Plant for Use in Mines and Ironworks." By Mr. J. H. Whittaker.

The question of coal-cutting has been the subject of the following papers:—

"Coal-cutting by Machinery." By Mr. R. W. Clarke.
"Mechanical Undercutting in Cape Colony." By Mr. John Colley.
"The Application of Coal-cutting Machines to Deep Mining." By Mr. W. E. Garforth.

Coal-washing has been the subject of the following papers:—

"Campbell Coal-washing Table." By Mr. Clarence R. Claghorn.
"The Craig Coal-washer." By Mr. William Scott.

The following papers have been contributed on the subject of coke-making:—

"Coke-making at the Oliver Coke-works." By Mr. Fred C. Keighley.
"The Production of Illuminating-gas from Coke-ovens." By Dr. F. Schniewind.

The following memoirs have been communicated:—

"Obituary of Thomas William Jeffcock." By Mr. Oscar J. Cotterell.
"Memoir of the late George Baker Forster." By Mr. R. H. Forster.
"Memoir of the late George Clementson Greenwell." By Mr. G. C. Greenwell.

The miscellaneous papers include:—

"Brick-making." By Mr. George L. Allen.
"Barometer, Thermometer, etc., Readings for the Year 1901." By Mr. M. Walton Brown.
"Legislation and the Ownership of Properties Containing Coal." By Mr. Daniel Jones.
"The Kitson System of Petroleum Incandescent Light." By Mr. Arthur Kitson.
"The Analytical Valuation of Gas-coals." By Mr. G. P. Lishman.
"Report of the Delegate of The Institution of Mining Engineers to the Conference of Delegates of Corresponding Societies of the British Association for the Advancement of Science, Glasgow, September, 1901." By Prof. Henry Louis.
"Coal-mining Subsidences in Relation to Sewerage-works." By Mr. F. W. Mager.
"Report of the Delegate of the North of England Institute of Mining and Mechanical Engineers to the Conference of Delegates of Corresponding Societies of the British Association for the Advancement of Science, Glasgow, September, 1901." By Mr. J. H. Merivale.
"A Visit to the Simplon Tunnel: The Works and Workmen." By Dr. Thomas Oliver.
"The Determination of the Calorific Power of Fuel." By Mr. S. L. Thacker.
"The Training of Industrial Leaders." By Prof. J. Wertheimer.

The preceding list, comprizing 94 papers, demonstrates the varied nature of the subjects printed in the *Transactions* (vols. xxii. and xxiii.) during the past year.

"Notes of Papers (115) on the Working of Mines, Metallurgy, etc., from the Transactions of Colonial and Foreign Societies and Colonial and Foreign Publications" have been continued, and should prove of value to the members.

Members can purchase, at privileged prices, copies of the *Transactions* of the following Corresponding Societies:—

The Australasian Institute of Mining Engineers.
The Canadian Mining Institute.
The Institution of Mining and Metallurgy.
The Mining Society of Nova Scotia.

Prof. H. Louis represented the Institution at the meetings of the Corresponding Societies Committee of the British Association for the Advancement of Science, held at Glasgow, in September, 1901; Mr. John Gerrard at the Jubilee proceedings of Owens College, Manchester; and Messrs. James Barrowman and M. Walton Brown on the London Committee of the International Engineering Congress held at Glasgow.

Since 1852, the date of the formation of the North of England Institute of Mining and Mechanical Engineers, considerable improvements have been adopted in methods of mining and metallurgical processes, accompanied by increased production of minerals and metals, and a decreased death-rate. A great part of these improvements is due to the development of societies devoted to the consideration of methods for the safe working of mines and the preservation of human life. And since that date the means of education for mining-engineers has been enhanced by courses of lectures provided at Universities and Technical Colleges; and examinations have been instituted for mine-manager's certificates. Mechanical appliances for getting minerals and improved explosives have become a necessity, ventilation is produced by fans on the surface instead of by underground furnaces, mechanical haulage has replaced horses, machine-holing is taking the place of human labour, and electricity has been introduced as a motive power for all classes of machinery.

The object of a technical society is not wholly attained unless there be adequate and critical discussion of the papers printed in the *Transactions*. Discussion is the test of the value of a paper, it makes known the experience of the speakers, and it directs attention to questions that may have been overlooked by the writer. The value of the *Transactions* would also be considerably increased by the addition of written remarks, sent to the Secretary, from members who are unable to attend the meetings.

The Local Institutes in Account with The Institution of Mining Engineers, for the Year Ending July 31st, 1902.

Dr.

	No. of Members.		Balance due at the beginning of the year.	Amounts falling due during the Year.			
	Federated.	Non-Federated.		Calls made during the year.	Excerpts.	Transactions, etc.	Totals.
			£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Midland Counties Institution of Engineers	316	...	15 4 0	300 4 0	1 5 2	16 6 8	332 19 10
Midland Institute of Mining, Civil and Mechanical Engineers	297	...	10 10 0	282 3 0	4 1 9	4 6 8	301 1 5
Mining Institute of Scotland	415	30	2 3 2	409 5 0	20 0 2	3 6 8	434 15 0
North of England Institute of Mining and Mechanical Engineers	1,215	...	70 6 0	1,154 5 0	20 7 6	29 11 8	1,274 10 2
North Staffordshire Institute of Mining and Mechanical Engineers	212	...	17 19 4	201 8 0	7 11 2	7 6 8	234 5 2
South Staffordshire and East Worcestershire Institute of Mining Engineers...	101	...	53 4 4	95 19 0	0 15 2	6 6 8	156 5 2
Totals	2,556	30	169 6 10	2,443 4 0	54 0 11	67 5 0	2,733 16 9

Cr.

	Amounts Paid during the Year.				Balance due at July 31st, 1902.
	Balance from previous year.	Calls.	Excerpts.	Transactions, etc.	Totals.	
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Midland Counties Institution of Engineers	15 4 0	285 0 0	1 5 2	16 6 8	317 15 10	15 4 0
Midland Institute of Mining, Civil and Mechanical Engineers	10 10 0	275 10 0	4 1 9	4 6 8	294 8 5	6 13 0
Mining Institute of Scotland	2 3 2	397 17 0	20 0 2	3 6 8	423 7 0	11 8 0
North of England Institute of Mining and Mechanical Engineers	70 6 6	1,084 18 0	20 7 6	26 11 8	1,202 3 2	72 7 0
North Staffordshire Institute of Mining and Mechanical Engineers	17 19 4	186 4 0	7 11 2	2 0 0	213 14 6	20 10 8
South Staffordshire and East Worcestershire Institute of Mining Engineers	38 0 4	47 10 0	...	...	85 10 4	70 14 10
Totals	154 2 10	2,276 19 0	53 5 9	52 11 8	2,536 19 3	196 17 6

Dr. THE TREASURER IN ACCOUNT WITH FOR THE YEAR

July 31, 1901.	£	s.	d.	£	s.	d.
To Balance at Bank, Current Account	338	19	3			
" " " Deposit Account	1,019	14	6			
" " in Cashier's hands	53	6	7			
				1,412	0	4
To Subscriptions for the Year ending July 31, 1901—						
Federated—						
Midland Counties Institution of Engineers	15	4	0			
Midland Institute of Mining, Civil and Mechanical Engineers	9	10	0			
Mining Institute of Scotland	0	19	0			
North of England Institute of Mining and Mechanical Engineers	70	6	0			
North Staffordshire Institute of Mining and Mechanical Engineers	12	7	0			
South Staffordshire and East Worcestershire Institute of Mining Engineers	31	7	0			
				139	13	0
To Subscriptions for the Year ending July 31, 1902—						
Federated—						
Midland Counties Institution of Engineers	285	0	0			
Midland Institute of Mining, Civil and Mechanical Engineers	275	10	0			
Mining Institute of Scotland	382	17	0			
North of England Institute of Mining and Mechanical Engineers	1,084	18	0			
North Staffordshire Institute of Mining and Mechanical Engineers	186	4	0			
South Staffordshire and East Worcestershire Institute of Mining Engineers	47	10	0			
				2,261	19	0
Non-Federated—						
Mining Institute of Scotland				15	0	0
Carried forward				£3,828	12	4

THE INSTITUTION OF MINING ENGINEERS. Cr.
ENDING JULY 31, 1902.

	£ s. d.	£ s. d.	£ s. d.	£ s. d.
July 31, 1902.				
By Printing—				
Transactions, vol. xx., printing	...197 5 11			
„ „ „ plates	...122 8 6			
		319 14 5		
„ „ xxi., printing	... 87 19 0			
„ „ „ plates	... 74 13 0			
		162 12 0		
„ „ xxii., printing	...424 2 5			
„ „ „ plates	...151 0 3			
		575 2 8		
„ „ xxiii., printing	... 72 8 2			
„ „ „ plates	... 44 4 1			
		116 12 3		
			1,174 1 4	
Excerpts, vol. xix.		0 10 6		
„ „ xx.		21 19 6		
„ „ xxi.		19 5 10		
„ „ xxii.		47 8 2		
„ „ xxiii.		11 6 7		
			100 10 7	
Proofs of Papers for General Meetings		.....	23 15 4	
Circulars		.....	17 10 8	
				1,315 17 11
„ Addressing *Transactions*, etc.		... ...	40 6 2	
„ Stamps—Circulars		14 13 0		
„ „ Correspondence		20 13 1		
„ „ *Transactions*		349 19 8		
			385 5 9	
„ Stationery, etc.		... ...	57 8 1	
„ Insurance of *Transactions*		... ...	3 0 0	
„ Binding—Library		3 14 11		
„ „ Sundries		2 15 0		
„ „ *Transactions*		0 5 3		
			15 2	
„ Reporting General Meetings		... ...	21 13 6	
„ Expenses of General Meetings		... ...	5 4 9	
„ Incidental Expenses		... ..	15 0 6	
„ Salaries, Wages, Auditing, etc.		... ...	565 15 0	
„ Indexing *Transactions*		... ...	27 10 0	
„ Travelling Expenses		... ...	61 17 11	
				1,189 16 10
Carried forward				£2,505 14 9

Dr. THE TREASURER IN ACCOUNT WITH

	£ s. d.	£ s. d.	£ s. d.
Brought forward			3,828 12 4
To Local Publications and Authors' Copies—	1900-1901.	1901-1902.	
The Institution of Mining Engineers... ...	0 0 0	56 9 4	
Midland Counties Institution of Engineers ...	0 0 0	1 5 2	
Midland Institute of Mining, Civil and Mechanical Engineers	0 0 0	4 1 9	
Mining Institute of Scotland	0 17 6	20 0 2	
North of England Institute of Mining and Mechanical Engineers	0 0 0	20 7 6	
North Staffordshire Institute of Mining and Mechanical Engineers	0 19 0	7 11 2	
South Staffordshire and East Worcestershire Institute of Mining Engineers	0 0 0	0 0 0	
	1 16 6	109 15 1	
			111 11 7
To Sales of Transactions, etc.—	1900-1901.	1901-1902.	
The Institution of Mining Engineers	0 5 0	177 8 6	
Midland Counties Institution of Engineers ...	0 0 0	16 6 8	
Midland Institute of Mining, Civil and Mechanical Engineers	1 0 0	4 6 8	
Mining Institute of Scotland	0 6 8	3 6 8	
North of England Institute of Mining and Mechanical Engineers	0 0 0	26 11 8	
North Staffordshire Institute of Mining and Mechanical Engineers	4 13 4	2 0 0	
South Staffordshire and East Worcestershire Institute of Mining Engineers	6 13 4	0 0 0	
	12 18 4	230 0 2	
			242 18 6
To Advertizements			581 11 10
To Address Labels			3 12 6
To Interest on Deposit Account			25 8 11
			£4,793 10 8

THE INSTITUTION OF MINING ENGINEERS.—*Continued.* Cr.

				£ s. d.
Brought forward	.....			2,505 14 9
By Advertizement Commission	.....			145 7 11
„ Translations of Papers	3 7 6			
„ Abstracts of Foreign Papers, vol. xx. ...	£12 6 5			
„ „ „ „ xxi. ...	5 0 0			
	17 6 5			
„ Barometer Readings, etc.	5 5 0			
„ Calendars	13 13 6			
„ Prizes for Papers in Volumes xviii. and xix.	20 0 0			
				59 12 5
				2,710 15 1
„ Balance at Bank, Current Account	487 11 1			
„ „ „ Deposit Account	1,544 18 5			
„ .. in Cashier's hands	50 6 1			
				2,082 15 7
				£4,793 10 8

We have examined the above account of receipts and payments, with the books and vouchers relating thereto, and certify that in our opinion it is correct.

JOHN G. BENSON & SON,
Chartered Accountants.

Newcastle-upon-Tyne.
August 7th, 1902.

THE INSTITUTION OF

BALANCE SHEET.—

Liabilities.

	£	s.	d.	£	s.	d.
Sundry Creditors—						
Advertizements paid in Advance	21	11	8			
Printing, etc.	1,458	0	0			
Postage of Transactions	240	0	0			
Abstracts of Foreign Papers in Volumes xxi., xxii. and xxiii.	150	0	0			
Barometer Readings	8	0	0			
Prizes for Papers in Volumes xx., xxi., xxii. and xxiii.	40	0	0			
Indexing Volumes xxi., xxii. and xxiii.	40	0	0			
Advertizement Commission, etc.	93	7	9			
				2,050	19	5
Balance of Assets over Liabilities				628	9	10

We have examined the above Balance Sheet, with the books and vouchers relating thereto, and certify that in our opinion it exhibits a correct view of the affairs of the Institution.

JOHN G. BENSON & SON,
Chartered Accountants.

Newcastle-upon-Tyne,
March 6th, 1903.

£2,679 9 3

MINING ENGINEERS.
JULY 31, 1902.

Assets.

	£ s. d.	£ s. d.
Balance at Bank, Current Account	487 11 1	
,, ,, Deposit Account	1,544 18 5	
,, in Cashier's hands	50 6 1	
		2,082 15 7
Subscriptions for the Year ending July 31, 1901, Unpaid—		
South Staffordshire and East Worcestershire Institute of Mining Engineers	.....	15 4 0
Subscriptions for the Year ending July 31, 1902, Unpaid—		
Federated—		
Midland Counties Institution of Engineers	15 4 0	
Midland Institute of Mining, Civil and Mechanical Engineers	6 13 0	
Mining Institute of Scotland	11 8 0	
North of England Institute of Mining and Mechanical Engineers	69 7 0	
North Staffordshire Institute of Mining and Mechanical Engineers	15 4 0	
South Staffordshire and East Worcestershire Institute of Mining Engineers	48 9 0	
		166 5 0
Local Publications and Authors' Copies, Unpaid—		
South Staffordshire and East Worcestershire Institute of Mining Engineers	.....	0 15 2
Transactions Sold, Unpaid—		
The Institution of Mining Engineers	4 13 6	
North of England Institute of Mining and Mechanical Engineers	3 0 0	
North Staffordshire Institute of Mining and Mechanical Engineers	5 6 8	
South Staffordshire and East Worcestershire Institute of Mining Engineers	6 6 8	
		19 6 10
Advertizements, Unpaid		395 2 8
		£2,679 9 3

BOOKS, ETC., ADDED TO THE LIBRARY.

African Review, London. Vol. xxviii., Nos. 461 and 462; vol. xxix., Nos. 463-475; vol. xxx., Nos. 476-488; vol. xxxi., Nos. 489-501; and vol. xxxii., Nos. 502-511.

Annales des Mines de Belgique, Bruxelles. Vol. vi., No. 4; and vol. vii., Nos. 1-3.

Australasian Institute of Mining Engineers, Melbourne. Transactions, vol. viii., No. 1.

British Association for the Advancement of Science, London. Report of the Seventy-first Meeting, held at Glasgow, in September, 1901. Demy octavo, cxx., 900 and 114 pages.

British Society of Mining Students, Medomsley. Journal, vol. xxiv., Nos. 1-6.

Chemical and Metallurgical Society of South Africa, Johannesburg. Journal, vol. ii., No. 9; and vol. iii., Nos. 1 and 2.

Cory Brothers & Company, Limited, Cardiff. British Coal and Freight Circular and General Export List, August 31st, 1901, to July 31st, 1902.

Engineering and Mining Journal, New York City. Vol. lxxii., Nos. 10-26; vol. lxxiii., Nos. 1-26; and vol. lxxiv., Nos. 1-8.

Engineering Times, London. Vol. vi., Nos. 3-6; vol. vii., Nos. 1-6; and vol. viii., Nos. 1-3.

Franklin Institute of the State of Pennsylvania, Philadelphia. Journal, vol. clii., Nos. 4-6; vol. cliii., Nos. 1-6; and vol. cliv., Nos. 1 and 2.

Institution of Mining and Metallurgy, London. Transactions, vol. ix.

Manchester Geological Society, Manchester. Transactions, vol. xxvii., Nos. 6-9.

Massachusetts Institute of Technology, Society of Arts, Boston. Technology Quarterly, vol. xiv., Nos. 3 and 4; and vol. xv., Nos. 1 and 2.

New South Wales, Department of Mines, Sydney. Annual Report, 1900.

—, Geological Survey, Sydney. Handbook to the Mining and Geological Museum, Sydney, with Special Reference to the Mineralogical Collections, by George W. Card. Demy octavo, 201 pages.

—, —, —. Memoirs, Geological Series, No. 2.

—, —, —. Mineral Resources, Nos. 9 and 10.

—, —, —. Records, vol. vii., No. 2

New Zealand, Department of Mines, Wellington. Annual Report, 1901.

—, —, —. Report of the Royal Commission appointed to Inquire and Report on the Working of the Coal-mines of New Zealand, 1901. Foolscap folio, 339 pages.

Queensland, Department of Mines, Brisbane. Annual Reports, 1900 and 1901.

—, Registrar-general's Department, Brisbane. The Queensland Official Year-book, 1901. Demy octavo, 425 pages.

Queensland Government Mining Journal, Brisbane. Vol. ii., Nos. 15-19; and vol. iii., Nos. 20-25.

South Wales Institute of Engineers, Cardiff. Transactions, vol. xxii., Nos. 5-8.

United States, Geological Survey, Washington. Annual Report, 1899-1900, parts i., ii., iii., iv., v. (with volume of maps), vi., vi. continued, and vii.

—, —, —. Reconnaissance in the Cape Nome and Norton Bay Regions, Alaska, in 1900, by Alfred H. Brooks, George B. Richardson, Arthur J. Collier and Walter C. Mendenhall. Imperial octavo, 22 pages.

—, —, —. The Geology and Mineral Resources of a Portion of the Copper River District, Alaska, by Frank Charles Schrader and Arthur Coe Spencer. Imperial octavo, 94 pages.

Victoria, Department of Mines, Melbourne. The Gold-fields of Victoria, Monthly Returns, July, 1901, to March, 1902.

Walker, Sydney F. Coal-cutting by Machinery in the United Kingdom. Excerpt from the *Colliery Guardian* Crown quarto 144 pages.

EXCHANGES.

Annales des Mines de Belgique.
Australasian Institute of Mining Engineers.
British Association for the Advancement of Science.
British Society of Mining Students.
*Canadian Mining Institute.
Chemical and Metallurgical Society of South Africa.
Franklin Institute of the State of Pennsylvania, U.S.A.
*Geological Institution of the University of Upsala, Sweden.
*Institution of Mechanical Engineers.
Institution of Mining and Metallurgy.
*Lake Superior Mining Institute.
Manchester Geological Society.
Massachusetts Institute of Technology.
*Mining Society of Nova Scotia, Canada.
*Natal, Geological Survey of the Colony of.
New South Wales, Department of Mines and Agriculture, Geological Survey.
*Revue Universelle des Mines, de la Métallurgie, etc.
South Wales Institute of Engineers.
*Transvaal, Department of the Mining Commissioner.
United States Geological Survey.

* No publications received during current year.

July 31st, 1902.

The meeting then divided into two sections for the reading and discussion of papers. Sir Lindsay Wood, Bart., presided over one section, and Mr. J. S. Dixon over the other section of the members.

Prof. G. A. Lebour's paper on "The Marl-slate and Yellow Sands of Northumberland and Durham," was read as follows:—

THE MARL-SLATE AND YELLOW SANDS OF NORTHUMBERLAND AND DURHAM.

By Prof. G. A. LEBOUR, M.A., M.Sc., F.G.S.

The Permian rocks—or, to speak more cautiously, the rocks which are newer than the Carboniferous and older than the Trias—in the North-east of England possess many peculiarities which distinguish them from deposits of the same age in the Midlands. and which differentiate them still more from those of Westmorland and Cumberland. Much controversy has from time to time taken place as to the true limits of that system, both upper and lower, in this region. Recently, moreover, a great deal of careful geological work, official as well as non-official, has shown—especially in the central coal-fields of England—that much of the formations formerly regarded as Permian has no right to the title, but belongs to the Coal-measure division of the Carboniferous. It appears to the writer, therefore, that it may be useful to take stock of the present state of our knowledge respecting those portions of the rocks in question which occur beneath the main mass of the system as it is developed in Northumberland and Durham, and constitute, in fact, its basement-beds.

The "main mass" of the Permian referred to in the last paragraph is, of course, the Magnesian Limestone, a very fit subject for discussion, but one which, in the present paper, it is proposed to touch upon, only in so far as it must be considered in connexion with the beds which, normally, lie beneath it. These beds are the Marl-slate and the Yellow Sands, and their general position in the geological series is best expressed in tabular form as follows:—

Permian:
- Magnesian Limestone.
- Marl-slate.
- Yellow Sands.

(Unconformity).

Carboniferous:
- Coal-measures.

The Yellow Sands.—In former days, the individuality of this very peculiar deposit was most unfortunately, but very naturally, misunderstood. It was so frequently seen lying upon red or mottled sandstone, the appearance of which was decidedly Permian, that the two were looked upon as a single group and the Yellow Sands merely as its upper part. This view was the more readily entertained as it enabled a close correspondence to be recognized between that portion of the stratigraphical column in England and in Germany. Thus the following erroneous correlation was adopted: —

Magnesian Limestone		Zechstein.
Marl-slate		Kupferschiefer.
Yellow Sands .. Red Sandstone ...	Lower New Red Sandstone ...	Rothliegendes.

It is true that it was, almost from the first, noted that the plant-remains which were found in the Red Sandstone were such as are also found in the Coal-measures, and not in any way characteristically Permian. This point was, however, made light of, and regarded as an indication that the physical break between the Carboniferous and Permian was one of no great importance.

As the country became more and more accurately surveyed, it became at last clear that though the Yellow Sands were, when present at all, always in the same stratigraphical position, that is, beneath the Marl-slate, this was not the case with the Red Sandstone. The latter, in fact, was at last seen to be beneath instead of above the denuded surface-plane upon which rocks newer than the Coal-measures had been piled up. Their un-Permian flora was thus explained, since these red beds were in truth themselves of Coal-measure age. Moreover, their apparent conformity with the overlying deposits was found to be entirely deceptive. Although the beds next below the Yellow Sands were usually red or mottled, it was by degrees proved that they were only here and there, and accidentally, in parallel stratification with the sands, and that almost as frequently they lay beneath them with discordant dips. It follows that they are not, as at first seemed obvious, always the same strata, but represent various horizons of the Coal-measures which assume a red or mottled colour generally increasing in intensity as they approach the plane of erosion. A strong, perhaps the strongest, confirmation of this view is, that of the many faults which dislocate the Coal-measures in the

Permian area of Durham the greater number affect these stained beds and leave the overlying sands unbroken. The Red Sandstone division may now, therefore, be dismissed from the Permian system altogether, though it probably will be long before all text-book writers, many of whom seem doomed to perpetuate error, will realize this.

The Floor.—The floor then, upon which the Permian rocks of the North-eastern counties rest, is a surface of erosion paved by the stained edges of denuded Carboniferous rocks. What that surface was like at the beginning of Permian times can be inferred more or less satisfactorily: (1) By considering the form of the land beyond the present Permian outcrop, where it is not covered by Glacial Drift and later superficial deposits, and allowing for the additional, and often profound, sculpturing which it has undergone since the removal of its Permian covering; and (2) by investigating the unaltered contours of that surface as it remains at the present day, buried beneath the Permian series of rocks.

The first line of investigation is of indirect value only. The evidence to be examined is so meagre, so much has been obliterated. Yet it leads to the belief—confirmed in other ways—that the floor formed a broad sloping plain of quite low gradient and but slightly undulating, reaching from what is now the Permian outcrop to somewhere between the 1,000 feet and the 1,500 feet contours on the eastern flank of the Pennine heights.

The second method gives results of certainty so far as they go, but these results are only attainable by borings and sinkings. Every record of a sinking or boring through the junction between the Permian rocks and the beds beneath them, like a sounding in the ocean, yields a truthful item or datum towards the construction of a contoured map of this ancient floor. The number of such sections is scarcely large enough to enable us yet to draw up a very full chart of this kind, but their number is increasing yearly, and, with the aid of the invaluable volumes of *Borings and Sinkings* published by the North of England Institute of Mining and Mechanical Engineers, the attempt is well worth the attention of some of the younger and more leisured members. At any rate, such information as is obtainable in this way tends to prove that the floor is simply a continuation of the one inferred above as once existing to the west, namely:—A gently sloping surface with

no hills or dales of any size, though not by any means perfectly plane, and dipping gradually beneath the present bed of the North Sea.

The Physical Break in Terms of Time.—It is necessary to pause here in order to draw attention to the meaning, in geological chronology, of the gap in the succession of deposits represented by this floor of erosion or unconformity, in order that its importance may be gauged. In years, or centuries, or tens of centuries, we cannot guess what it represents, but a brief enumeration can be made of some of the more notable events which undoubtedly took place during that time-gap. Briefly they are as follows:—

(1) That portion of the Coal-measures, which now is no longer present, was deposited bed by bed and seam by seam. How many feet of rock this may have been we do not know, but as there is every reason to suppose that there are, in this district, none of the beds known in some other coal-fields as the Upper Coal-measures,* the thickness is probably great.

(2) The broad, flat and enormously thick series of Carboniferous rocks having been completed, vast earth-movements occurred in the form of great parallel anticlinal folds with intervening synclinals, one set running approximately north and south (of which the Pennine saddle or "backbone" is one of the best standing witnesses) and another approximately east and west. The uppermost Carboniferous beds—the Coal-measures—were thus deformed into alternate domes and depressions. Faulting accompanied this folding.

(3) All the upper strata were exposed to long-continued denudation which, with greater or less regularity, removed huge portions of the rocks forming the domes above mentioned, eroding them in places so as to uncover rocks even earlier than the Lower Carboniferous, and smaller portions of the more protected beds in the hollows, the remains of which are our present coal-fields.

When the denudation last referred to had reached the point at which the Coal-measures that are now covered by younger rocks still stand, the earliest deposits of the next system, the Permian, began to accumulate upon the floor prepared for them by these various phenomena, denudation going on, however, as

* Though, as a matter of convenience, it is the custom to call the beds, from the High Main seam upward, by that name.

it has gone on ever since, wherever no such deposits were forming, as in the higher ground along the Pennine ridge, for instance.

The first deposit thus to accumulate was the one known as the Yellow Sands. It is a most peculiar rock. As its name denotes it is a sandy mass, the grains of which are often so loosely held together as to crumble in the fingers, often, however, cemented together by carbonate of lime, sometimes almost as compact and coherent as a typical grit or sandstone. But it is not gritty in the true sense; that is, its grains are not angular bits of quartz bounded by irregular or conchoidal fractures. The grains, which are of moderate size, often quite coarse, are almost invariably well rounded. They are exactly similar to grains of desert sand, wind-worn and unprotected from attrition by a film of moisture such as helps to preserve the sand-grains of a sea-bottom or of a beach. Then the Yellow Sands are false-bedded in the highest degree, and false-bedded exactly in the manner exhibited by sections in the dunes of deserts. They contain no fossils, or at least none which may not have been derived from earlier formations, such as fragments of Coal-measure plants. They are probably nowhere much more than 100 feet or so in thickness, often only a few feet thick and sometimes altogether wanting. They fill up the shallow depressions of the denudation-surface on which they lie, and their base-line necessarily follows the irregularities of that surface. Here and there, as has already been said, the bed is a cemented and fairly compact stone, but the writer believes that this state is merely due to the local leaching downwards of carbonate of lime from the thick overlying limestones, and that the loose type is the normal state of the Yellow Sands. Indeed, were it not for its unsuitability as regards the exceptionally coherent portion of the deposit, the term "quicksands" might very well be applied to the whole formation as, indeed, it is in Yorkshire and Nottinghamshire. The upper surface of the Sands is much more regular than the bottom, although the great variations in thickness and occasional absence of the bed have led many to suppose that the very opposite of this is the case. The state of things as regards the mode of occurrence of the deposit and its relations to the rocks above and beneath will be best understood by a glance at Fig. 1, which is

meant to represent an ideal section parallel with the strike of the Permian strata.

It appears to the writer that the claim of the Yellow Sands to be regarded as the basement-bed of the Permian, where they occur, is exactly analogous to that of the conglomerate, which (in Ribblesdale and along the Pennine escarpment) lies on the edges of the denuded Silurian and Ordovician rocks and beneath the Mountain Limestone, to be considered the basement-bed of the Carboniferous in those regions.

FIG. 1.—References: R, Stained Coal-measures, the Red Sandstone of early writers; Y, Yellow Sands; R and Y together represent the Rothliegendes of early writers; and M, Marl-slate.

As to the nature of their origin, it is perhaps allowable to differ. The late Sir Andrew C. Ramsay in 1871 wrote:—"The Yellow Sands at the base of the limestone-beds are generally a residue of sand. The limestone, which is often sandy, rests on shale, which is comparatively impermeable to water. The limestone dips east; the carbonate of lime has been carried away in solution as bicarbonate; and the sand remains."* It is sufficient to state, in opposition to this view, that the grains of sand which are sometimes present in the Magnesian Limestone are quite unlike those of the Yellow Sands in character, and that where such grains are most plentiful they yet form so very small a percentage of the limestone that a bed such as that now being dealt with would, if a residue, represent a vanished mass of limestone greater than all that is left in the overlying divisions of the Permian—so great as to be scarcely conceivable. In 1890, the late Mr. R. Howse, than whom none was more familiar with the question, suggested that the deposit "may have been an Eolian accumulation of sand . . . . before the Magnesian Limestone began to be thrown down,"† and with this view the present writer is disposed to agree. If this windblown mode of accumu-

* "On the Red Rocks of England of Older Date than the Trias," *Quarterly Journal of the Geological Society of London*, 1871, vol. xxvii., page 245.

† "Catalogue of the Local Fossils in the Museum of Natural History," by Mr. Richard Howse, *Natural History Transactions of Northumberland, Durham and Newcastle-upon-Tyne*, 1890, vol. x., page 252.

lation be the true one, it follows that only imperfect conformity is to be expected between the sands and the Marl-slate, and here again the facts are in accord with the theory.

As the Yellow Sands are now seen, there are some marked features which are obviously of later origin than the sands themselves. These are especially the results of the segregation of carbonate of lime, when that happens to be abundant, in thick or thin irregular anastomosing veins or ribs such as those so strikingly exhibited in Cullercoats Bay, and in more or less spherical concretions such as are also common in the same place and elsewhere. If a fragment of one of these ribs or of one of the concretionary knobs is suspended in a vessel full of acidulated water, the cementing calcium carbonate soon dissolves away and the rounded grains of quartz are freed and fall to the bottom. The veins or ribs play, in places, a rather important and not, the writer believes, a very generally recognized part in connexion with the flow of water through the Sands.

So loosely compacted a deposit, lying as this one does between rocks of much closer texture, is naturally water-bearing in the highest degree, and this property has long been turned to useful purpose for water-supply. Its utility is, however, counterbalanced by its evil consequences in mining operations. It has more than once been noticed that the flow of water—into borings, for instance, or into galleries driven to tap the water—has been considerably less than the extent and thickness of the water-holding bed had led one to expect. It is the opinion of the writer that this is sometimes due to the presence of ribs such as those above referred to. Where they are abundant they tend to form obstructions to the natural flow of the water within the bed and, locally, to separate the latter into more or less completely dammed-in compartments or chambers. When one such reservoir has been pumped dry, or partly so, its refilling from the adjoining water-holding sandy cisterns is impeded, according as the ribs forming its walls act as perfect barriers to the circulation, or, as is more usually the case, only as partial barriers through which the water is filtered but slowly. Several cases of anomalous water-supply failures, or semi-failures, can be accounted for in this way.

Another point connected with the Yellow Sands as a water-bed is deserving of mention and is, the writer thinks, new and of

some importance as regards the present enquiry, inasmuch as it may help to explain some of the irregularities of thickness which are among their most remarkable characters. It is this: Wherever the Yellow Sands crop out at the foot of an escarpment of Magnesian Limestone (their usual mode of occurrence at the surface) and where this outcrop is not completely covered up, and consequently sealed, by Boulder Clay, natural springs issue. The writer has noticed that where such springs have been long undisturbed and where the Sands from which they issue are of the incoherent or quicksand type, there occurs below the spring-mouth under favourable conditions quite a small flattish "cone of dejection" of sand which has obviously been brought by the spring current from within the rock. In most cases, of course, such sand is removed to lower ground by streams, but by careful observation it can be shown that a considerable amount of sand has in the course of time been carried away from its original stratum, though no doubt at irregular intervals. In this way, then, it is thought that the subterranean erosion which has gone on for so long must have extensively altered the distribution of the sand within the beds. From this it follows that, as some of the matter is removed from the lower portions of the Sands, these must, here and there, become less able to support the upper layers of the deposits which may thus in time be let down as well, occasionally, as portions of the overlying Marl-slate or Magnesian Limestone.* Some of the inequalities observed in certain localities at the base of the Marl-slate may, therefore, be due to agencies at work long after the deposition of that stratum and, consequently, be no evidence of original discordance of stratification between that formation and the Yellow Sands. For it should be clearly understood that though the Sands and the Marl-slate each lie upon a floor which is sometimes very uneven, yet the nature of the junction is essentially different. The Sands are thickest in the hollows of their floor, but the Marl-slate is not thicker where the surface upon which it lies is a depression than elsewhere. As the late W. Hutton remarked, many years ago, of a section then visible in Rough Dean, Houghton-le-Spring, the slaty limestone (or the

* For accounts of similar action in drift-deposits, see Prof. G. A. Lebour, *Natural History Transactions of Northumberland, Durham and Newcastle-upon-Tyne*, 1893, vol. xi. page 191; and Blake's *Annals of British Geology for 1893*, pages iii. and 12; and Mr. Wm. Shone, *Quarterly Journal of the Geological Society of London*, 1892, vol. xlviii., page 96; and *Geological Magazine*, 1893, decade 3, vol. x., page 323.

Marl-slate) is there seen "resting upon the Sand, sometimes in a very uneven line, the limestone appearing to bend round and conform itself, to the inequalities of the Sand."* Figs. 2 and 3 explain what is meant. The basins holding the sands were, in fact, in all cases pre-existent; those holding the Marl-slate are many of them subsequent to its deposition. That it is advisable to lay stress upon this point is proved by the inability which some authors have shown to distinguish between the great unconformity at the base of the Sands and the merely apparent or "contemporaneous" unconformity between them and the Marl-slate.†

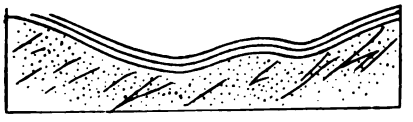


FIG. 2.—DIAGRAM SHEWING THE MARL-SLATE ADAPTING ITSELF TO THE IRREGULARITIES OF THE FLOOR BENEATH IT.

Before leaving the Yellow Sands, it may be useful to give some analyses showing their chemical composition, as that composition has a notable bearing upon the question of the origin of the Sands and of the cause of the staining of the Red Beds beneath them. The analyses are selected, from a number published in 1866, by Messrs. Browell and Kirkby, so as to exhibit the great variation in the percentage of carbonate of lime which may exist in the sands in even neighbouring localities. A is a more solid variety, owing to the amount of calcareous cementing-matter present, B is of the more usual incoherent kind; and both are from Ryhope colliery.

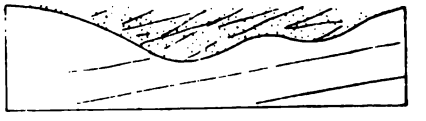


FIG. 3. -DIAGRAM SHEWING THE SAND FILLING THE IRREGULARITIES OF THE FLOOR BENEATH IT.

* "Notes on the New Red Sandstone of the County of Durham below the Magnesian Limestone," by Mr. Wm. Hutton, *Transactions of the Natural History Society of Northumberland, Durham and Newcastle-upon-Tyne*, 1830-1831, vol. i., page 65.

† "The Permian Formation in the North-east of England," by Mr E. Wilson, *Midland Naturalist*, 1881, pages 97-101, 121-124, 187-191, 201-208. Referring to the Quicksand division of the Permian, it will surprise Durham miners to find Mr. Wilson saying: "It is not certain that this rock is present in Durham. The unconsolidated sand-rocks that are so frequently seen beneath the Magnesian Limestone in that county are now properly classed with the Carboniferous system. It is doubtful whether it has been met with in any of the colliery-shafts, sunk through the limestone" (page 101); and again, speaking of the Marl-slate, he says: "The rapid fluctuations of these beds are evidently owing to their resting on an uneven floor of Carboniferous rocks." It is curious to note that Mr. Wilson has quite clearly realized the Permian age of the "Quicksands" of Yorkshire, where they are far less markedly developed than they are in Durham.

	A.	B.
Carbonate of lime	20·48	0·39
Carbonate of magnesia	1·52	—
Oxide of iron and alumina ..	6·16	10·20
Silica, soluble in dilute acid ...	0·16	—
Sand, clay, etc.	72·88	89·33
Water	—	0·47

In some cases, the iron oxide is as low as 1·28 per cent.*

The Marl Slate.—Already a good deal has been said respecting this early calcareous member of the Permian, in considering its usual precursor—the Yellow Sands. The general mode of junction between the two beds has been explained. It must now be added that there are other modes displayed in certain localities. At Tynemouth, for instance, the Marl-slate is separated from the sands by a bed of massive Magnesian Limestone of the same character as that above, on which the Priory stands. At Cullercoats, a few thin beds of Magnesian Limestone occur in the uppermost portion of the Yellow Sands heralding the Marl-slate, as it were. At Claxheugh, the "Slate" suddenly comes to an end at the eastern extremity of the exposure, and its place is taken by massive Magnesian Limestone.† These three sections exhibit the less usual relations of the two deposits.

On the whole, the Marl-slate may be described as a thin and, considering its thinness, a remarkably persistent and characteristic set of flaggy greyish, bluish, brownish, sometimes even blackish limestones and shales equally distinct from the Magnesian Limestone on the one hand and from the Yellow Sands on the other. It is certainly a marine deposit, since it contains such shells as *Nautilus Freieslebeni*, *Lingula Credneri*, *Discina Koninckı*, and *Myalina Hausmanni*, that is to say a Cephalopod, Brachiopods, and a Lamellibranch, but these fossils are exceedingly scarce, and in the same beds have been found several kinds of remains of land-plants imperfectly preserved, such as *Neuropteris Huttoniana*, *Caulopteris (?) selaginoides*, and *Polysyphonia (?) Sternbergiana*. It is clear that, though the beds were formed in sea-water, they were formed by no means far from land, and probably at or very near the mouth or estuary of a river, or the mouths

* *Natural History Transactions of Northumberland and Durham*, 1866, vol i., pages 206 and 207.

† An excellent explanation of the well-known but always puzzling section at Claxheugh has been given by Mr. David Woolacott, in the *Quarterly Journal of the Geological Society of London*, 1898, vol. liv., page 14.

of several streams bringing down the fern-fronds and other vegetable débris from the Pennine high ground.

But the chief peculiarity of the Marl-slate is the large number of extraordinarily complete and well preserved fishes which it has yielded. Moreover, these fishes are of kinds which leave us in doubt as to whether they lived in salt-water or in fresh-water. They belong to such genera as *Palæoniscus*, *Pygopterus*, *Acrolepis*, *Cœlacanthus*, *Platysomus*, the nearest existing rare analogues of which now inhabit rivers and lakes. Together with these are the remains of amphibia such as *Lepidotosaurus*, and of some true reptiles such as *Proterosaurus*. We have thus a fauna which is the reverse of frankly marine, and at the same time not entirely fluviatile or lacustrine. The only reasonable inference seems to be that this fauna is of an estuarine or lagunal kind; that is, existed close to land where the water was probably brackish, where flooded rivers brought down creatures from purely inland waters to become mixed with others belonging to the marginal regions of the sea.

It has been mentioned that the fish-remains are singularly perfect. It is also noticeable that most individuals, as Mr. William Hutton, who first made the observation, wrote "are contorted; not that sort of twisting which might be produced by any movement in the mass, and subsequent to the time they were enveloped, but the graceful contortions of the living animal in a state of pain, as if struggling against its fate." Whether one agrees or not with Mr. Hutton in regarding these petrified convulsions as graceful, it must be admitted that his conclusion that the death of these fishes seems to have been due to some sudden catastrophe is a reasonable one since "it is a generally received opinion, that where the remains of soft-bodied animals occur, with their outward form perfectly preserved, and associated in families [groups], they have been suddenly overwhelmed, and entangled in the substance forming their stony matrix."* Such a sudden overwhelming is a likely one under estuarine conditions, or in lagoons fringing the land, where occasional inroads of abnormal tides might cause destruction among the fresh-water or even brackish-water creatures involved in them.

It has been stated above that the Marl-slate is in some places preceded by earlier calcareous beds, and that sometimes even there

* *Op. jam cit.*, page 71.

is an alternation of sands and limestone-bands beneath the Slate. In such cases we have, in fact, an actual passage from the Sands to the Slate, so that there is, at such places, not even the appearance of unconformity between the two. There is, further, rare but positive evidence of the sandy conditions not having everywhere come to an end before the deposition of the Marl-slate.

In the local notes, which follow, will be found a case or two where a bed of sand occurs above the Yellow Sands. Such evidence should be conclusive as to the close connexion between the Sands and the great Magnesian Limestone of the Permian, of which the Slate is but the usual first stage.

The history of the beginnings of the Permian system in Northumberland and Durham, such as it can be gathered from the facts already stated and from the details with which this paper concludes, seems fairly obvious.

(1) A mass of sand, probably chiefly derived from the waste of the Carboniferous Sandstones which formed so large an area of the then land-surface to the west, occupied a broad tract of coast from somewhere to the north of Hartley, in Northumberland, to Yorkshire and still farther south, narrower in the north than in the south. This sand was a beach at the coast-line and a desert of blowing dunes elsewhere. Rivers, sluggish and probably inconstant (changing their course as do the channels in a delta) wound their way to the sea across this sandy tract, and added to the irregularities of its surface.* The deposition of calcareous and magnesian mud in the thinly bedded layers which betoken tranquil deposition followed, due partly to silting from landwards and from tidal irruptions from sea-wards most probably in a chain of coastal lagoons. This was accompanied by a downward movement of the coast-line and the gradual merging of the lagoons into the sea proper when the Magnesian Limestone, with its curious fauna—a marine fauna checked in its existence by the unfavourable chemical composition of the Permian sea-water to which the rock owes its dolomitic character—was deposited. This view is

* The late Prof. A. H. Green was of opinion that the Quicksands (that is, our Yellow Sands) are the deltas of the streams which emptied themselves into the inland sea. *Geological Magazine*, 1872, vol. ix., page 101. The entire absence of fossil-remains, the form of the grains, and the nature of the cross-bedding seem to point rather to wind as the final distributor of the sand, though Prof. Green's view may quite well be accepted for their first accumulation.

strongly confirmed by the occasional exceptions to the rule that the Marl-slate precedes the Magnesian Limestone proper which have already been referred to, such exceptions (where limestone occurs beneath the Slate) being obviously the result of local accidental breaches of the bars separating the lagoons from the sea.

A number of detailed thicknesses of the beds dealt with in this paper, together with other notes, are given in the Appendix. Such a list would have been impossible before the publication of the admirable *Borings and Sinkings* by the North of England Institute of Mining and Mechanical Engineers. Much difficulty has in many cases been experienced in identifying the beds described in the accounts of borings (sinkings are necessarily much better evidence) and in some of these cases the author has ventured to disagree with previous interpretations. Where the strata are visible to the day he has visited the localities himself, usually many times, and he would wish to take this opportunity of acknowledging the great assistance which was given him in these examinations by the Rev. John Dunn, D.C.L., in the middle eighties.

No doubt in the interpretations in the Appendix some errors must have been committed, and if the publication of such a list elicits accurate information, it will have served its end. The occurrence of water, even in large quantities, at the Permo-Carboniferous junction is, by itself, no guide. There may be much water and no Yellow Sands, and, though much more rarely, the converse may be true. The late Mr. S. C. Crone pointed out long ago that the Sands held more water to the north and east than to the south and west.

Among the papers which should be consulted by all wishing to go more fully into the palæontological and other details of the Marl-slate than has been attempted here, those by Prof. Sedgwick, Mr. Richard Howse, Mr. Kirkby and Dr. William King hold the first place, and very little has been done since their time.

APPENDIX.– THICKNESS AND OTHER PARTICULARS OF THE MARL-SLATE AND YELLOW SANDS FROM NORTH TO SOUTH IN NORTHUMBERLAND AND DURHAM.
Nota Bene.—Numbers given thus (vol. ii., page 132) refer to the volume and page of the *Borings and Sinkings*, where the full sections are to be found.

No.	Locality.	Marl-slate. Ft Ins.	Yellow Sands. Ft. Ins.	Remarks.
1	Hartley	Denuded	+15 0	Capping the cliff in small outliers, just south of the old Limekiln.
2	Cullercoats	3 0	+70 0	On the coast between the Ninety-fathoms Dyke and the northern end of the "Baths." Thin limestones in the upper part of the sands. Marl-slate highly fish-bearing.
3	Whitley Quarries ..	3 6	(?)	Top of sands only reached.
4	Tynemouth Cliff ...	3 0	22 0	The sands thin to less than 10 feet here to the west.
5	South Shields ..	Denuded	(?)	The sands have been met with in the immediate neighbourhood, but details are wanting.
6	Harton Toll Bar ..	Denuded	(?)	The sands were formerly visible here (Mr. W. Hutton).
7	Simonside, near Westoe	0 11 (?)	None	*Boring* (vol. v., page 155).
8	West Boldon ...	(?)	Thin	In cutting the foundations of a house below the quarry and below the church, and in a well near the Rectory gate (Mr. W. Hutton).
9	Down Hill, near West Boldon	2 6	+10 0	Fish found in the Marl-slate here.
10	Hylton Castle, near	(?)	Thick	"In dell running from the Wear to Hylton Castle" (Mr. W. Hutton).
11	Pallion	7 0	Thick	
12	Claxheugh	Nil to 4 0	Very thick	Mr. W. Hutton describes the yellow sands here as of immense thickness. They are certainly more than 70 feet.
13	Wearmouth Colliery	8 10	5 0	*Sinking* (vol. iv., page 96).
14	Humbledon Hill ...	9 10	+10 4	*Sinking and boring* (vol. iii., page 270). Here there is a thin bed of yellow sand (6 inches thick) immediately above the Marl-slate. The thick sands are described as yellow above and brown below.
15	Pensher Hill ...	(?)	Thick	Sands seen on north side of hill.
16	Silksworth Colliery	2 6	7 0	*Sinking* (vol. v., page 151), No. 1 Shaft.
17	Ryhope Colliery .	1 1	96 6	*Sinking* (vol. iv., page 322), North and West Pits. In this section, the sands are divided into ten members chiefly characterized by variety of colouring, dark, white, brown and yellow. Fish occurred in the Marl-slate.
18	Seaham	3 0	8 4	*Boring* (vol. v., page 41). Thickness of sands doubtful.
19	Seaham Colliery ...	(?)	8 6	*Sinking* (vol. v., 42), Union Pit. Marl-slate no doubt present, but not identifiable.

APPENDIX.—*Continued*.

No.	Locality.	Marl-slate. Ft.	Ins.	Yellow Sands. Ft.	Ins.	Remarks.
20	Seaham	4	2	6	0	*Sinking*, 1849 (vol. v., page 45). Thickness of sands doubtful.
21	Eppleton Colliery ..	(?)		36	0	*Sinking*. Downs Pit. The sands were in this case dry.
22	Do do. ...	(?)		110	9	*Sinking* (vol. ii., page 301). Jane Pit.
23	Murton Colliery .	2	6	34	6	*Sinking* (vol. iv., page 116). East Pit.
24	Do. do. .	2	0	27	8	*Sinking* (vol. iv., page 117). Middle Pit.
25	Do. do. ...	3	3	26	0	*Sinking* (vol. iv., page 120). West Pit. What has been taken here as Marl-slate is given as 2 feet 3 inches of blue metal and 1 foot of white metal. What the latter may be is doubtful.
26	Hetton	4	6	2	4	*Boring*, 1793 (vol. iii., page 219). This is a very doubtful section; a limestone 1 foot 8 inches thick is said to underlie the "marl with sand in open gullets" which is here taken as the Yellow Sands.
27	Elemore Colliery ...	1	3	62	10	*Sinking* (vol. ii., page 275). George Pit. The upper part of what is probably the Marl-slate is said to be a "yellow clay."
28	Do. do. ...	1	7	63	0	*Sinking* (vol. ii., page 277). Isabella Pit. In this case the lower portion of the probable Marl-slate is said to be clay.
29	South Hetton Colliery	2	0	None		*Sinking* (vol. v., page 162). Engine Pit.
30	Easington	2	4	(?)		*Boring* (vol. ii., page 266). The sand was merely touched by the boring.
31	Haswell ...	(?)		24	2	*Boring* (vol. iii., page 168) near Shotton.
32	Haswell Colliery .	3	3	60	0	*Sinking* to sand, then *Boring* (vol. iii., page 169). Engine Pit, 1831.
33	Do. do.	(?)		None		*Sinking* (vol. iii., page 169). Engine Pit, 1833.
34	Haswell	(?)		143	8	*Boring* (vol. iii., page 172). No. 1 hole. The upper 69 feet of the sand was dry. Beneath the sand are 13 feet 7 inches of "soft freestone or sand with grey metal partings." If this forms part of the sand, then the total thickness would be the enormous one of 157 feet 3 inches.
35	Do. .	(?)		None		*Boring* (vol. iii., page 173). No. 2 hole. 4 inches of yellow clay occurs in this section immediately below the Magnesian Limestone or Marl-slate.
36	Do.*	3	9	108	0	*Boring* (vol. iii., page 173). No. 3 hole. The bottom of the sand was not reached.

* Mr. T. Y. Hall states that, at the Old Haswell Pit, the quicksands (or the Yellow Sands) were 120 feet thick; that in one borehole "where the present pit is" there were none whatever, and that in the next one the hole was in 96 feet of sands. "The Extent and Probable Duration of the Northern Coal-field. *Trans. N. E. Inst.*, 1854, vol. ii., second edition, pages 178 and 179.

APPENDIX.—*Continued.*

No.	Locality.	Marl-slate. Ft	Ins	Yellow Sands. Ft.	Ins.	Remarks.
37	Shotton, near ...	12	3 (?)	24	2	*Boring* (vol. v , page 145). The Marl-slate is probably not more than 3 or 4 feet thick at most.
38	Shotton Colliery ...	3	8	24	3	*Sinking* (vol. v., page 146). Engine Pit. The beds here taken as Marl-slate are given in the section as strong blue limestone, in thin pannels, 2 feet 4 inches, and blue and grey metal, 1 foot 4 inches. Possibly the latter only is the Marl-slate.
		or 1	4			
39	Do. ...	3	4	37	0	*Sinking* (vol. v., page 148). New Pit, 1840. Here again the Marl-slate is in two beds, the lower of which is 1 foot 4 inches.
		or 1	4			
40	Ludworth Colliery...	3	4	(?)		*Sinking* (vol. iv., page 41). Here the section beneath the Marl-slate is: Grey and brown post, 29 feet 8 inches; metal parting, 4 inches; and red and grey post and water, 18 feet. If the whole represent the sands, they would be 48 feet.
41	Thornley Colliery ...	1	6	36	0	*Sinking* (vol. v., page 273).
42	Castle Eden Colliery	12	0	12	0	*Sinking* (vol. ii., page 18). Maria Pit. Perhaps the bottom 10 inches only (described as grey metal) of what has been here taken as the Marl-slate is to be properly so called.
43	Houghton-le-Spring	5	0	60	0	Many fishes were got from the Marl-slate here. The latter has at its base thin brown clay in layers, alternating with the calcareous slabs.*
44	Kelloe	1	1 (?)	None		*Boring* (vol. iii., page 287) by the side of the lane from Kelloe to Cassop Hill.
45	Kelloe Colliery	2	10	None		*Sinking* (vol. iii., page 289). North Pit, East Hetton or Kelloe Colliery.
46	Kelloe	(?)		None		*Boring* (vol. iii., page 290). Low part of Kelloe royalty. 21 feet 7 inches of alternating blue limestone and dark metal represents the Marl-slate.
47	Kelloe Colliery ...	3	10	None		*Sinking* (vol. iii., page 291). New Pit. Probably the "dark metal" here taken to mean the Marl-slate is the lowest number of the alternations mentioned in the last note.
48	Coxhoe	2	0	1 11 (?) or None		*Boring* (vol. ii., page 151), 1840. The Yellow Sands may be absent altogether. The 1 foot 11 inches bed given here is described as a "strong grey post, with water," and is possibly Coal-measures.

* Mr. W. Hutton, *op. jam cit.*, page 65, says that from Houghton-le-Spring towards Moorsley and Pittington, and in the quarry at Thickley, an unctuous clay, as well as alternations as above described, is common at the bottom of the Marl-slate.

APPENDIX. - *Continued.*

No.	Locality.	Marl-slate.	Yellow Sands.	Remarks.
		Ft. Ins.	Ft. Ins.	
49	Coxhoe Colliery	(?)	(?)	*Sinking* (vol. ii., page 152). New Winning, 1843. The information in this section is useless for the present purpose.
50	Cornforth	(?)	None	*Boring* (vol. ii., page 110).
51	Do.	5 2	None	*Boring* (vol. ii., page 113). "Hills and Holes."
52	Cornforth ...	4 0	None (?)	*Boring* (vol. ii., page 119). 1839. 600 feet west of Garmondsway Public-house. "Brown post with water, 12 feet, may possibly represent the Yellow Sands here.
53	Do.	4 0	None (?)	*Boring* (vol. ii., page 120). 1842. South of Symside Hill. Here again 5 feet 5 inches of "brown sandy post" may represent the Sands.
54	Cornforth Colliery...	3 6 (?)	None	*Sinking* (vol. ii., page 123). George Pit. Here the basement-bed of the Permian is said to be "blue limestone with post girdles," 10 feet.
55	Garmondsway Moor Colliery	5 9 (?)	None	*Sinking* (vol. iii., page 77). West of Anne pit.
56	Garmondsway Moor	2 0 (?)	None	*Boring* (vol. iii., page 77). ½ mile south of pit.
57	Do. do.	1 10	None (?)	*Boring* (vol. iii., page 79). Second hole, 1840. Here a bed of sand 4 inches thick is recorded 18 feet above the Marl-slate. "Brown post with water, 11 feet" beneath the Marl-slate may possibly represent the Sands.
58	Trimdon Grange Colliery	(?)	None	*Sinking* (vol. v., page 322). 1845.
59	Do. do.	0 9 (?)	None (?)	*Sinking* (vol. v., page 323). New Pit, 1872. What has here been taken as the Marl-slate is a thin bed called "strong metal girdle," beneath which come 26 feet of "hard blue limestone, full of spar." Below this again are 22 feet of "soft white post, with partings"; this may be the Yellow Sands? Above the 9 inches (?) of Marl-slate are 4 feet 2 inches of "soft dark gritty sand." A very abnormal section.
60	Trimdon Colliery ...	1 6	20 10	*Sinking* (vol. v., page 318), "sunk in Trimdon staple," 1842. The section of the Sands is here very complete, namely: Light yellow sands, 4 inches; yellow clay-partings, 12 feet; dark yellow sands, 8 feet 6 inches. The middle member is specially interesting.

APPENDIX.—*Continued.*

No.	Locality.	Marl-slate. Ft.	Ins.	Yellow Sands. Ft.	Ins.	Remarks.
61	Trimdon Colliery ..	(?)		14	9	*Sinking* (vol. v., page 320), 1843. The Marl-slate is no doubt a portion of what is given in this section as 37 feet 6 inches of "dark metal" lying on the Sands, which here consist of 14 feet 6 inches of "brown sandy post with soft partings and water" with 3 inches of "yellow partings" at top.
62	Rodridge or South Wingate Colliery	3	11	31	0	*Sinking and Boring* (vol. iv., page 314). 1841.
63	Thrislington ...	10	0 (?)	None		*Boring* (vol. v., page 282). 1,050 feet north by east of the Hall.
64	Do. ...	4	6	None		*Boring* (vol. v., page 285). Fourth hole, "in the first sinking pit," 1836.
65	Do. ...	?		None (?)		*Boring* (vol. v., page 288). Eleventh hole, 600 feet north of first pit, 1837. A difficult section. The beds about the Permo-Carboniferous junction are given thus: *Permian*?: Gullety limestone, 6 feet 3 inches; sand, 2 feet; red and grey metal, 1 foot; limestone, 6 feet; brown post with water, 2 feet. *Coal-measures*?: Red and blue metal, 1 foot 6 inches; sand, 6 inches; and dark metal, 2 feet 6 inches.
66	Do. ...	?		None (?)		*Boring* (vol. v., page 289). Twelfth hole, Whinney Hill. A "white post" 5 feet thick may represent the Yellow Sands.
67	Do. ...	3	6	None		*Boring* (vol. v., page 290). 639 feet "from the Old Coal Pit."
68	Thrislington Colliery	4	0	None		*Sinking* (vol. v., page 291). Jane Pit, 1867.
69	Ferry Hill	3	2	None (?)		*Boring* (vol. iii., page 30). Fifth hole, 1836, east end of Ferry Hill.
70	Do.	13	4	None (?)		*Boring* (vol. iii., page 32). If there be any yellow sands here, they are but 3 feet thick.
71	Fishburn	6	7	None		*Boring* (vol. iii., page 38). "Near Fishburn."
72	Do.	1	0 (?)	None		*Boring* (vol. iii., page 39). Third hole, "in Miss Chilton's Quarry," 1837.
73	Hardwick	?		None		*Boring* (vol. iii., page 137). No. 1 hole, 1,500 feet from Sprucely Farmhouse.
74	Do.	4	9	None (?)		*Boring* (vol. iii., page 138). No. 2 hole, 450 feet from Bishop Middleham Village, 1839. A thick "brown freestone with water" may possibly represent the Sands.
75	Great Chilton ...	9	4	None		*Boring* (vol. ii., page 38). 1828.

APPENDIX.—*Continued.*

No.	Locality.	Marl-slate. Ft.	Ins.	Yellow Sands. Ft.	Ins.	Remarks.
76	Little Chilton ...	1	6	6	5 (?)	*Boring* (vol. ii., page 39). 1834.
77	Do. ...		?	19	0 (?)	*Boring* (vol. ii., page 41). 1838.
78	Chilton Colliery ...		?	69	0 (?)	*Sinking* (vol. ii., page 43). No. 1 Shaft, 1872. The sands in all these Chilton sections are doubtful
79	Mainsforth Colliery	15	6 (?)	None		*Sinking* (vol. iv., page 48). B Pit.
80	Bishop Middleham Colliery	9	6	None		*Sinking* (vol. i., page 147). Bishop Middleham Pit, 1846.
81	Ryal		?	?		*Boring* (vol. iv , page 320). 1874. Although this is a diamond-boring, yet the record leaves one quite in the dark as to the details of the junction-beds; "limestone" and "sandstone" is all that is given.
82	Rickwall Grange ...	2	0	None (?)		*Boring* (vol. iv., page 305). 1875. Here again, though the Marl-slate is given, it is not possible to say whether the "grey post" which come below and is underlain by "yellow sandstone," may not possibly represent the Yellow Sands.
83	Middridge ...	11	0	None		*Boring* (vol. iv., page 85). 1,500 feet south-east of village, 1837.
84	Middridge Colliery		?	None (?)		*Sinking* (vol. iv., page 86). Charles Pit. A "yellow post" immediately beneath the limestone may possibly represent the Yellow Sands.
85	East Thickley	4	6	None		*Boring* (vol. v., page 267). Right hand of lane leading to Middridge, 1834.
86	Nunstainton	13	0	None		*Boring* (vol. iv., page 196). 2¼ miles east of Rusheyford.
87	Do.		?	None		*Boring* (vol. iv., page 198). 240 feet south from Stoney Hall.
88	Do.	2	0	None		*Boring* (vol. iv., page 199). In field near Standalone.
89	Seaton Carew		?	None		Diamond-boring, 1888. The 40 feet of dark grey limestone is the lowest Permian in this section, and of this the bottom portion may be Marl-slate. The 27 feet 6 inches of grey and red sandstone beneath are in all probability Coal-measures and not "Lower New Red Sandstone" as given in the record. (Mr. W. J. Bird, *Trans. Manchester Geol. Soc.*, 1888, vol. xix., page 572.)*

Trans. Inst. M.E., 1890. vol. i., page 343

Mr. J. B. Atkinson (H.M. Inspector of Mines, Newcastle-upon-Tyne) said that the Marl-slates, which were described in Prof. Lebour's paper as *kupferschiefer*, produced copper-ore. Prof. Lebour made no reference in his paper to the composition of the Marl-slate, and he (Mr. Atkinson) asked whether any appearance of copper had been observed in the county of Durham. He believed that copper-ore had been observed in the Magnesian Limestone about Gardmondsway, but he did not know whether it occurred in the Marl-slate.

Mr. David Burns said that no copper was found in Cumberland in the corresponding beds, and he thought that there was no trace of copper in the Durham district. He had spent a few weeks among the corresponding strata in the Perm district, where copper was very prevalent.

Mr. J. T. Stobbs (Stoke-upon-Trent) wrote that, as might be expected, Prof. Lebour's paper was an able summary of our present knowledge of the relation of the Permians to the Coal-measures in North-eastern England. Of the junction-beds, the Permian Yellow Sands, when present, offer peculiar difficulties in shaft-sinking, and later in the extraction of the upper coal-seams, chiefly because of their natural incoherence and their water-bearing character. Hence, any contribution to the knowledge of the laws of their distribution would be most welcome to those responsible for the development of the eastern portion of the Durham coal-field. It has been ascertained that this distribution is somewhat erratic, and that the Yellow Sands fill the hollows of an old-land surface (that is the floor), which, generally speaking, slopes to the east. General knowledge, however, on this point is not enough, and detailed information respecting these indentations is the great desideratum at the present time, so that the existence or absence of these beds beneath the Magnesian Limestone may be predicted, at any given locality. He (Mr. Stobbs) could not agree with Prof. Lebour's statement that "every record of a . . boring through the junction between the Permian rocks and the beds beneath them . . . . . yields a truthful item or datum towards the construction of a contoured map of this ancient floor."* The Appendix shows no

* *Trans. Inst. M.E.*, 1902, vol. xxiv., page 372.

less than 30 borings, which report an absence of the Yellow Sands at this junction, and he (Mr. Stobbs) was of opinion that the greatest caution should be exercised in accepting negative evidence from a bore-hole in ground of this character, especially if put down by a system employing hollow rods, down which water is forced. Parallel cases might be quoted from the Ballarat district of Victoria, where shafts, sunk through basalt overlying the denuded Silurian, were completely lost by the inrush of water-bearing "drift," which was reported by bore-holes (put down within the last 25 years) as non-existent. With respect to the time-measure of the unconformity between the Permians and the Coal-measures, it might be pointed out that the "earth-movements" and "denudation" of sections (2) and (3)* were undoubtedly, to a large extent, contemporaneous. The time required for denudation of a given thickness of rocks depended very largely on their hardness, and their position: at any rate, he (Mr. Stobbs) was not inclined to exaggerate the time necessary for the removal of the Upper Coal-measures in Northumberland and Durham, some patches of which were now known to exist in place in Northumberland.

Mr. Walcot Gibson (London) contrasted the difference in the character of the basal beds of the Permian in the North of England with that in Nottinghamshire on the south, where the basal Permian was a strong breccia-band of great service to the miner. The Eolian origin of the Yellow Sands would form one more link in the evidence connecting the Permian and Triassic rocks into one system. He was glad to see attention drawn to the correct age of the red rocks beneath the Yellow Sands. In Nottinghamshire, the Permian rested quite discordantly on at least two horizons of red sandstone—on one high up in the Coal-measure sequence, and on another much lower down. The question as to the nature of the Permo-Carboniferous boundary was one of great interest, alike to the miner as to the geologist, and had received but scanty attention of late years. Signs of a revival of interest were therefore welcome.

Prof. G. A. Lebour (Durham College of Science) wrote, in reply to Mr. Atkinson, that to his knowledge no copper-ore had been found in the Marl-slate of Durham or Northumberland.

* *Trans. Inst. M.E.*, 1902, vol. xxiv., page 373.

Abroad, carbonate of copper was very common as an impregnation in that deposit—hence its name *kupferschiefer*. At Garmondsway, as Mr. Atkinson stated, copper-ore occurs in the Magnesian Limestone, but in distinct veins of copper-pyrites, weathered externally into green carbonate of copper, not disseminated through the stone. It is quite possible, though he (Prof. Lebour) thought that it had not yet been proved, that this vein, or other similar veins, if traced below into the Marl-slate, will there prove to be still copper-bearing, but not in the manner in which the bed is copper-bearing in the typical *kupferschiefer* of the Continent. The persistent association of copper with the Permian abroad is a most striking phenomenon, and one which has not yet been fully accounted for. In northernmost England, however, this association is not marked, since the infilling of a fissure-vein need not have any direct connexion with its containing walls at any given point. The subject did not, therefore, come within the scope of his paper.

The PRESIDENT (Sir Lindsay Wood, Bart.) moved a hearty vote of thanks to Prof. G. A. Lebour for his interesting paper.

Mr. M. WALTON BROWN seconded the resolution, which was cordially approved.

The Rev. W. NALL read the following paper on "The Alston Mines":—

THE ALSTON MINES.

By the Rev. W. NALL, M.A., Alnham Vicarage.

History of the Mines.—The earliest fragment of authentic information concerning the Alston mines is contained in a document dated A.D. 1131. It is an account of certain moneys, which were due to the King from the burgesses of Carlisle in respect of a certain mine, called the Carlisle silver-mine, which was held by them from the King under a lease.

Subsequent accounts enable us to identify the so-called silver-mine of Carlisle with the lead-mines of Alston. Lead-ore contains silver—in various proportions—in combination with the lead; that obtained from Alston moor contains about 10 ounces of silver to the ton of lead. The Rev. John Hodgson—to whose researches we are mainly indebted for our knowledge of the early history of the Alston mines—states that the Northumberland Pipe Roll of 1226 contains a charge of £2,154 for the old rent of the mine of Carlisle, and that this charge is carried forward annually through the whole of that reign, that is to say, until 1272.* Assuming the reliability of Mr. Hodgson's information, we are safe in concluding that the Alston mines were, during that early period, very rich; for £2,154 of that age represents the large sum of £10,000 of our current coin. And yet this sum represented only the rent of the mines, and it did not include the profits realized by the lessees, nor the expenditure for labour and mining requisites.

The expression "old rent," which occurs in the Northumberland Pipe Roll, suggests the idea that the Alston mines were even at that time considered to be old. It may be inferred from the facts just adduced, and from the further fact that the church at Alston was built and the parish formed in 1154, that there was a considerable population in the district in the twelfth and thirteenth centuries. The rent obtained from the lessees of the mines formed a considerable proportion of the revenue of the

* *History of Northumberland*, 1840, vol. iii., part ii., page 45.

Crown, and is sufficient to account for the interest which the Kings of England took in the lead-mines and for the privileges which they granted to the miners.

Henry III., in 1234, warned his bailiffs and faithful people that he had taken under his protection and defence all his mines of Aldeneston (Alston), their men, lands, goods, rents, and all their possessions, and, therefore, commanded them to maintain, protect and defend them, neither giving them nor suffering them to receive from others, hindrances, injury, loss or trouble; and if they had suffered by forfeiture, forthwith to make them amends. In 1235, a royal mandate signified to all the miners in Cumberland that, on repairing to work at the King's mines at Aldeneston, they should not only go there safely and securely, but enjoy all the liberties and free customs, which the miners there had been accustomed to have in times past; and also directed the Sheriff of Cumberland that he should cause all the miners in his bailiwick to go and dig and mine there in his bailiwick, as they had done in times past; and also, the merchants to repair to the same mine with victuals for the miners.*

The wording of the charter suggests the inference that the King had no other mine in Cumberland than that at Alston. Together with the other liberties which the miners enjoyed, was one which gave serious trouble to the landowners and farmers; as they were allowed to cut down the trees, and use the wood in the mines. One case of dispute is cited by Mr. Hodgson as follows: "In Michaelmas term, 1290, Patric of the Gill and 26 other miners at Aldeneston were empleaded by Henry de Whitby and Joan his wife, for cutting-down their trees at Aldeneston by force and arms, and carrying them away." The defence set up by the miners was that they enjoyed the privilege, granted to them by their lord the King, of cutting down the wood, to whomsoever it might belong, which was nearest to the silver-vein, and to take as much of it as they pleased to roast and smelt the ore, to build and to hedge, to give to the agents in lieu of wages, and to the rich in order that they might distribute it to the poor. They also affirmed that the lords of the woods had no right, after that they (the miners) had begun the work of cutting down, to sell or give any of the wood, excepting for reasonable needs, and that they had enjoyed the liberty from time immemorial.†

* *History of Northumberland*, 1840, vol. iii., part ii., page 46.

† *Ibid.*, pages 47 and 48.

The charter of protection having been burnt by the Scotch, Edward III. renewed it on October 23rd, 1334; and again on October 5th, 1335. The King, in 1350, wishing to ascertain what were the liberties, customs and immunities which the miners at Alston and their predecessors had enjoyed, commissioned Thomas de Seton and John de Mowbray to institute an enquiry; who thereupon empanelled a jury at Penrith for that purpose. The jury reported that the miners dwelt together in their shelis [*cf.* shieling], had the liberty of choosing from among themselves one coroner, and one bailiff, who was called the King's Serjeant. The coroner had cognizance of all pleas concerning felonies, debts, and all other matters concerning themselves, and had the power of determining cases. The bailiff was empowered to enforce the decisions of the coroner. There was, however, a proviso to the effect that the miners ceased to enjoy their privileges when they ceased to dwell together in "shelis."

At some time previous to 1359, the Carlisle lessees had either surrendered or forfeited their lease of the mines, for a German, named Tilman, was then in possession of the mines, and had brought over a colony of his own countrymen and settled them on Alston moor. The change of lessees was probably followed by a change of market. While the burgesses of Carlisle were in possession of the mines the produce was no doubt carried to that ancient city and there sold to the lead-merchants; but the Germans seem to have sent the lead, or lead-ore, by way of Stanhope or Hexham to Newcastle, whence it was shipped to the continent—probably to Hamburg. Alston was thus separated from its own county-town of Carlisle, and brought into connexion with Newcastle.

In 1414, the mines were leased by William de Stapleton: and in 1468, Edward IV. granted to Richard, Earl of Warwick, and John, Earl of Northumberland and others, all his mines of gold and silver. On March 23rd, 1475, the King granted to his brother, the Duke of Gloucester, Henry, Earl of Northumberland and others, the mines of Fletchers, which were situated at Gerrard's Gill in Alston parish.

Towards the end of the sixteenth century, the Alston estates, together with the mines, became the property of the Hyltons, of Hylton Castle, near Sunderland. In 1621, Hylton, the lord of the manor, being desirous of providing his daughter with a

marriage-portion, raised the requisite sum by granting leases for one thousand years of the several tenements upon his Alston estates, reserving to his family the right of working the lead and other mines on payment of damages to the lessees. His successor, finding that the mines were not remunerative, and supposing that they were exhausted, sold the property to the Radcliffes, of Dilston. The story of James Radcliffe, the last Earl of Derwentwater, is well known and does not need to be re-told. One of the consequences of the Pretender's attempt upon the throne of England was the settlement of the Derwentwater estates, with the mines, upon the Greenwich Hospital.

The history of mining in Alston moor during the past 150 years would furnish matter for a small volume, but the writer proposes to mention here only the more important facts.

In 1737, most of the mines in Alston moor were held on lease by a Company which was popularly known as the London Lead Company, or the Quaker Company, but traded under the name of the Governor & Company. This Company is still in possession of lead-mines in Teesdale, but in 1882 the directors sold their interest in the Alston mines to the Nenthead & Tynedale Lead & Zinc Company.

During the long tenure of the lease of the Alston mines by the Governor & Company, the mineral resources of the district were thoroughly explored, every vein being carefully traced and mapped, and every stratum being pierced through and through by shafts, adits and drifts. The output of lead-ore, which in the ten years between 1737 and 1747 was only 15,244 bings,* continued to increase, until it reached its maximum of 217,846 bings, valued at £1,000,000, in the decade from 1817 to 1827.

In the trials which were made by the Governor & Company for the purpose of exploring the veins, other minerals, in addition to lead-ore, were discovered, and were to some extent utilized.

Mineral Veins.—A few of the most productive veins which traverse the district of Alston moor may be mentioned here:—The Rampgill vein has probably been one of the most productive in Great Britain. During the period between 1703 to 1886 the

* 1 Bing weighs 8 cwts.

output of ore from this vein in the Greenwich Hospital Manor was 350,000 bings, and almost as much ore was obtained from the same vein by Mr. Beaumont in the Allen's Head mines.

The story of the Hudgill-burn mine is a striking exemplification of the proverb that fact is stranger than fiction. In 1888, the late Mr. Thomas Wilson-Crawhall-Wilson, of Alston, supplied the writer with the following information respecting that famous mine: —

> This mine was originally in the hands of two separate companies. One of these drove the Hudgill-burn level to a considerable distance towards the west, or south-west, but failing to discover ore, the agents abandoned the enterprise. About the same time, a person named Todd, who held a plot of mining ground near Galligill, which he explored by means of shafts, also abandoned his lease. Report says that ore was subsequently found within a yard of one of Todd's shafts.
>
> The mining field was now open to any one who cared to try his fortune, and it was at this juncture (1813) that Mr. John Wilson of Nent Hall formed a new company for the purpose of working both the abandoned plots of ground. This company commenced operations in the Hudgill-burn level. Diverting the level from its former course, they drove it towards the south, and entered Todd's old ground, where they cut the Hudgill old vein in the course of the following year, 1814. In subsequent years, they cut other rich veins, and continued for a long time to raise large quantities of ore and to pay large dividends.
>
> During the first year the total expenditure was about £400, no ore being discovered. In 1815, ore, to the amount of 563¼ bings, was raised. In 1816, a dividend of £1,680 was paid; in 1817, the dividend was £7,000; and it continued to increase until in 1822 the maximum of £38,000 was reached. The total amount divided among the partners during the seventeen years that the mine continued to be productive was £320,000, which allows an average dividend of £17,500 per annum. The original capital was £500.

Other wellknown mines include Rodderup Fell, Benty Field, Tynebottom, Cash Well and Cross Fell. The writer reserves for further notice the trials which have been made from time to time in the Great Sulphur vein.

Summary.—Between the years 1737 and 1887 the quantity of lead-ore extracted from the mines on the Greenwich Hospital Manor was upwards of 1,600,000 bings; for the whole of Alston moor the quantity must have exceeded 2,000,000 bings. From 1797 to 1827, and again from 1847 to 1867 the average price per bing was £5. A moderate computation of the value of the lead-ore yielded by the Alston mines, during the period of 150 years, between 1737 and 1887, would not fall far short of £20,000,000.

For 21 years, beginning with 1800, the average output per annum from the mines in Teesdale, Weardale, the Allendales and Alston moor with Cross Fell, was as follows:—

Mining Districts.	Bings.
Teesdale	8,000
Weardale	17,000
Allendales	8,000
Alston Moor, with Cross Fell	19,000

In the year 1788, the output of the Weardale and the Allendales mines was 11,391 bings; and of Alston (the Greenwich Manor only) 10,593 bings. During the last quarter of the eighteenth and the first quarter of the nineteenth century, the Alston mines were probably the richest lead-mines in the world.

The royalty on lead-ore in Alston moor during the long period between 1737 and 1828 was at the rate of 1 in 5; from 1828 to 1835, the royalty was 1 in 6 on the east bank of the Tyne and 1 in 7 on the west bank; from 1835 to 1863, it was 1 in 7 over the whole manor; and since 1863 it has varied from 1 in 7 to 1 in 18.

Men who were distinguished for their attainments in natural science travelled from a distance to see the rich lodes and heaps of ore within and near the mines. Among the visitors were Prof. Mohs, of Freiberg, and Count Breuner, of Vienna. Dr. Buckland, Dean of Westminster, inspected the mines, and studied the geology of the lead-mining districts. In 1815, the Dean of Windsor, in his capacity of Director of the Royal Hospital for Seamen at Greenwich, visited the mines, and after inspecting Nent Force level, he characterized it as "a stupendous work," quoting the expression from the report of a former commissioner.

Alston moor was, in those days, a training school, whence mine-agents and engineers were sent to other mining-fields. The Assay Office in Alston was a school of practical science, in which discoveries were made that have been of immense advantage to the owners of mining property and to the country generally. In this office, Mr. H. Lee Pattinson made his famous discovery of a new method of extracting the silver from lead, a discovery which is supposed to have added £5,000 per annum to the revenue derived from the Weardale mines.

In 1796, an attempt was made to obtain Parliamentary power to make a canal from Newcastle to Haydon Bridge. The follow-

ing extracts, taken from a petition presented to the House of Commons by the Commissioners of the Greenwich Hospital, indicate the opinion which then prevailed with regard to the commercial value of the Alston mines.

The canal, by ending as is proposed at Haydon Bridge, will terminate in the very centre of the said Barony of Langley, a situation peculiarly favourable for a repository of wood, iron, and other articles which will be brought from Newcastle for the use of the very valuable lead-mines belonging to the Hospital in the manor of Alston moor; and for the corn and merchandise which will be brought for the supply of the town and neighbourhood of Alston, whereby that country and all the estates of the Hospital there, will be greatly benefitted and improved. That Langley lead-mills, for the smelting of Alston ore, belonging to the Hospital, and Blagill lead-mills, are so situated as to derive very great benefit in point of carriage, as by means of the proposed canal a ready communication will be formed for the conveyance of the Hospital's and the Blagill Company's lead to Newcastle; and for carrying back wood, iron, bricks, and other heavy articles necessary to and used at those mills in return, by which and the other benefits and advantages above mentioned, and by divers others, the revenues of the said Hospital will, if the said Bill shall pass, and the said canal be made, be considerably increased and the estates of the Hospital there in other respects considerably benefitted and improved.

The following is an estimate of the annual savings in the expense of the carriage of lead and materials, if the proposed canal should be made to Haydon Bridge, compared with what is now paid; which includes the other lead-mills at which the lead-ore of Alston moor is smelted:—

No.	Names of Mills, etc.	Owners of Mills.	Present Expense	Estimated Expense by Canal.			Estimated Saving.		
			£	£	s.	d.	£	s	d.
1	From Langley Mills to Newcastle (Alston ore)	Commissioners & Governors of Greenwich Hospital	720	407	10	0	312	10	0
2	Blagill Mill to Newcastle (Alston ore)	William Jobling & Co. (an Alston Company)	720	407	10	0	312	10	0
3	Capold Mill to Newcastle (Alston ore)	Governor & Company ...	1,440	815	0	0	625	0	0
4	Nenthead	Governor & Company ..	720	407	10	0	312	10	0
5	Tynehead	Utrick Walton & Co. .	480	271	13	4	208	6	8

N.B.—The foregoing estimate is made upon an expectation that 12,000 pieces of lead will be produced annually at each of the mills Nos. 1, 2, and 4: 24,000 at the mill No. 3; and 8,000 at the mill No. 5. Upon examination of the books kept in the office of the receivers of the Hospital, it is found that in the last seven years, 85,127 pieces of lead have been sent from Langley mills to Newcastle. From hence [*sic*] it cannot be doubted of how much importance it is for the interest of the Greenwich Hospital that the proposed canal on the north side of the river Tyne should be effected.

Geology and Mineralogy.—It is a fact well known to the geologist, that the north-country dales closely resemble each

other in their physical features, and that they have all been formed by the same agencies in the same series of rocks. The rivers Tees, Tyne and Wear have their sources in the same mountain—Kilhope being only a spur from Cross Fell—and in their upper reaches flow within a few miles of each other. From Wear Head to Tyne Head the distance is not more than 6 miles; and from Tyne Head to Tees Head it is not more than 8 miles. At one point in its course, the Tees approaches so near to the Tyne that a mining-engineer was able some years ago, without much difficulty, to conduct some of the water of the former river into the latter. The Tyne-bottom Limestone—a stratum which has derived its name from the fact that it forms the bed of the South Tyne for several miles—appears in the bed of the Tees near the source of that river, and in the bed of Kilhope burn near Heathercycleugh, and is in both these places underlaid by the Great Whin Sill. The Fell Top Limestone crops out on Blagill Fell and Middle Fell in Tynedale, and on the summits of the Weardale and Teesdale fells.

Between the Whin Sill and the Fell Top Limestone lie the Lead-measures, which derive their name from the fact that they are rich in deposits of lead-ore. Of this series of rocks the central mass of the Pennine chain is mainly composed, and to it the dalesmen are indebted for their beautiful scenery.

Near the middle of the Lead-measures occurs the Great Limestone—the characteristic stratum of the series—which forms so striking a feature in northern landscapes. It crops out in great thickness in Tynedale, Allendale, Weardale, Teesdale, and the dales in North Yorkshire. In Tynedale, it forms a natural terrace of great beauty, which runs along the eastern side of the valley from Lovelady Shield to a point above Kirkhaugh church. A partial section of this limestone has been exposed in the quarry at Coatlith hill.

In Weardale, this stratum forms terraces on the sides of the hills and mountains; but nowhere does it appear to greater advantage, as the maker of rich scenery, than in the bed of the Tees near Barnard Castle. The "living-stone and marble-grey," which occur in *Rokeby*, are poetic expressions for limestone, and

> "Those cliffs that rear their haughty head
> High o'er the river's darksome bed"

are, to speak in the language of sober prose, " limestone tumblers." But though the dalesmen are indebted to the presence of the Great Limestone for their grandest and fairest scenes, it is to the Whin Sill and the Scaur Limestone of the Lead-measures that they are indebted for those natural rockeries which ornament the banks of the rivers, and form the beautiful waterfalls.

The geology of Alston moor may be studied with advantage in the bed of the South Tyne and in the gills which score the slopes of the mountains. The Whin Sill lies near the surface in the village of Garrigill and crops out at Tynehead, while Cross Fell is capped by the Grindstone Sill.

Shafts have been sunk into the Whin Sill at Garrigill, Rodderup Fell and Tees-side. In the Browngill mine, lead-ore has been found in the Grindstone Sill, that is to say, at the very top of the Lead-measures. At Rodderup Fell and on Tees-side lead-ore has been found in the Whin Sill, or at the bottom of the Lead-measures. A careful examination of the list of mines given in Mr. Westgarth Forster's *Treatise on a Section of the Strata from Newcastle-upon-Tyne to Cross Fell* would, the writer believes, show that every stratum between the Grindstone Sill and the Whin Sill has been pierced by the lead-miner in his search for ore. The composition and texture of each stratum have been ascertained and its position in relation to the other strata has been fixed with a considerable degree of accuracy. These remarks apply to the lead-mining districts of Alston moor, the Allendales, Weardale and Teesdale.

The writer will venture to digress for a moment from the subject of this paper, in order to point out that the miner was the pioneer in the science of geology and that our knowledge of the strata and mineral veins has been mainly derived from him. When the antiquity of the Alston mines is considered, the number of men employed in them either as agents or workmen, and the probability that many of the agents were men of ability, the force of this remark becomes apparent.

The geology of Alston moor was the subject of careful study on the part of Thomas Smeaton—the famous engineer—prior to 1776. In that year, the Nent Force level was commenced under the direction of Smeaton. The level was intended to serve the

two-fold purpose of a drain for the Nenthead mines and of a trial of the mineral veins in the Nent valley.* The designer must, therefore, have had some knowledge of the strata in the Nent valley or he could not have devised his working-plans.

It is interesting to note here that William Smith was only seven years of age when Smeaton's great engineering work was commenced. Therefore, the statement made by Prof. Seeley in *The Story of the Earth* that "The law of succession of the layers of rock upon each other" was not discovered until 1790, and then by William Smith, needs some qualification.

Mineral Veins.—In Alston moor most of the veins run in a direction which may be roughly described as east-and-west. A few bear north-and-south, crossing the east-and-west veins at various angles.

The veins which cross other veins are, of course, of more recent origin than those which are crossed by them; hence the belief which is prevalent that the east-and-west veins were anterior in origin to the north-and-south veins. If we might assume that the vein-fissures were caused by shrinkage in the earth's crust, we should arrive at the conclusion that the fissures in the Pennine district were caused by two distinct movements in the earth—the first in respect of time being from north to south, and the other, and more recent, from east to west.

All the veins traverse the Whin Sill, and are consequently of later origin than that sheet of basalt.

The Great Sulphur Vein, or Backbone.—Any account of the geology of Alston moor which did not take notice of the Backbone or Great Sulphur vein, would be incomplete. The writer has, therefore, made a few notes on that vein. Its course is nearly north-west to south-east, being parallel with the course of a dyke of basalt which crosses the Tyne at some distance to the south-west. The proximity and parallelism of those two powerful dykes are circumstances worthy of notice. In what respects do the contents of the Sulphur vein differ from the contents of the other

* The distance from the mouth of the Nent-force level to the first air-shaft, at Nentsbury, is 3 miles. This section was driven on the dead-line (level), and the carriage of materials was effected by means of boats, the level being filled with water to a depth of 4 feet. The next air shaft is at Welgill: about 1 mile above Nentsbury. This section was driven at a higher random (elevation) than the first, and the carriage was effected by means of a railway. The total cost of the level is said to have been upwards of £90,000.

veins in the Alston district? This question cannot be satisfactorily discussed here, because the information respecting the vein is not yet sufficient to enable a definite opinion to be formed upon the subject. Towards the north-west, the Sulphur vein runs into the Pennine fault; towards the south-east it becomes divided into several weak sections; and finally it disappears in the mountain-barrier which divides Weardale from Upper Teesdale and Upper Tynedale. The vein throws up the south-west side to the extent of 180 feet, thus placing the Tyne-bottom Limestone on the one side on a level with the Scaur Limestone on the other side.

In 1820, the Commissioners for Greenwich Hospital re-opened the old workings in Crossgill by means of a level under the Scaur Limestone, which served the purpose of a drain for the mine. They also pierced the north side of the vein, wherein they discovered a collateral string, which contained some copper-pyrites, associated with malachite.

To the north-west of the high ground which forms the watershed between Crossgill burn and Black burn, a little stream, well known to the miners and shepherds as the Cash burn, takes its rise and flows almost due north until it joins the Black burn. The Sulphur vein appears in the bed of this stream, and the ruins of old mines are distinctly visible. Two shafts have been sunk into the vein, and a quantity of pyrites brought to the surface. Still farther north-west, in the Smittergill burn, a trial was made by Messrs. Paul & Co., and a small deposit of lead-ore was discovered.

Towards the south-east, near the confluence of the Clargill and Darngill burns, a little lead-ore was obtained from the vein, and trials were made in it on the top of Yad Moss, by the late Mr. Jacob Walton, of Green Ends, Nenthead. The results of those trials were not such as to justify a further expenditure of capital.

The above facts seem to show that the contents of the Great Sulphur vein are poor in quality, that the deposits of lead-ore are too few and small to repay the cost of mining operations, and that copper and sulphur are not present in the pyrites in sufficient quantities to repay the cost of extraction. But it should be borne in mind that the processes for extracting metals have been greatly improved since the above trials were made, and that ores which were formerly regarded as worthless rubbish are now being

turned to good account. Our forefathers buried thousands of tons of black-jack (blende) in the dead-heaps, believing that the material was of no use; but the blende is now being disinterred, and from it is extracted a metal which is more valuable than lead.

In 1872, the Tynehead Manor, which is the property of Colonel Byng, was surveyed by Mr. De Rance, who made the following remarks on the contents of the Sulphur vein:—

> No assay of magnetic pyrites (pyrrhotite) from the Sulphur vein has been made. It is possible that it may be associated with the valuable metals, cobalt and nickel, as is the case in some German ores; and whether this be so or not, it is certain that it contains a sufficient quantity of sulphur to make it valuable for the manufacture of crude sulphuric acid. The residues obtained from the pyrites, in the manufacture of sulphuric acid, are employed, when pure, as iron-ore, in Cleveland, under the name of "blue billy."

In the early part of the nineteenth century, a valuable deposit of copper-ore was discovered in the Stow Crag vein, Tynehead, and a smaller deposit was found in the Sir John's vein. Both of these veins are closely associated with the Great Sulphur vein. The bearing of the Sir John's vein is almost due north-and-south. It traverses the left bank of the South Tyne, from Dry burn to Tynehead, crossing the river at a point which is a short distance to the west of the confluence of the Darngill burn with the South Tyne. The Sulphur vein crosses the river, a little farther to the west, and as its course is north-west to south-east, it intersects the Sir John's vein on Yad Moss, and removes it from its course to the extent of 120 feet. Both veins disappear on Tynehead fell.

Copper.—Small quantities of copper have been found in the Sulphur and Sir John's veins at Crossgill and Tynehead. One valuable deposit was discovered in the "hazel," about the middle of the last century in the Stow-crag mine (Tynehead) in the Sir John's vein.

Limestone of excellent quality abounds in Alston moor.

Three seams of coal occur in the Lead-measures, of which the two associated with the Little limestone were formerly utilized for domestic and agricultural purposes. Crow coal has now disappeared from the domestic hearth, though it is still used in the lime-kiln.

This account of the Alston moor mining district is not exhaustive—the names of many veins having been omitted. Among the

veins passed over are Carrs, Cowhill, Cow Slitt, the Great Cross veins in Handsome Mea and Rampgill mines, Black Ashgill, Low Fair Hill, Patterdale and Galligill, Woodhouse, Hanging Shaw, and Scraith Head, in the Nenthead district; and the following in Garrigill: Thortergill, Old Groves, Howhill and Hardsyke. Every one of those veins has been the subject of one or more trials, and some of them have yielded ore; but none of them can be relied upon as a source of mineral wealth.

The cross veins are not productive, excepting at, or near, the places where they intersect the east-and-west veins, and in most of those places they have already been tried.

The minerals found on Alston moor include:—Alstonite: anthracite; barytes, sulphate and carbonate; baryto-calcite; black-jack or blende; calamine; copper; fluor-spar; galena, the principal ore of lead; iron pyrites; limestone; and quartz, the chief mineral in the Sulphur vein.

The PRESIDENT (Sir Lindsay Wood, Bart.) said that the members were very much obliged to Mr. Nall for his interesting paper on the ancient working of the mines in the Alston district. The quantity of ore got in those days was very much larger than was produced at the present time on account of the best mines having been very largely exhausted. These mines were not now being worked, owing to the great fall that had taken place in the price of lead—50 per cent., if not more—and that, of course, made a great difference when they had to work the poorer mines and those below water-level. The mines at Alston were now, he believed, worked for zinc, the lead being a bye-product, instead of *vice versa* as in the olden days.

Mr. ANTHONY WILSON (Thornthwaite, Cumberland) said that he had listened with interest to the history of the Alston mines. Reference had been made to the working of the mines in the early days by the Germans, and history had repeated itself, as the whole of the workings at present being carried out round and about Alston were now practically in the hands of a German company, who worked them on a highly scientific basis. The Institution of Mining Engineers would do great good if it were to consider this subject, and obtain papers on lead- and zinc-mining in Great

Britain. One could not help but think that if downright energy and capital were put into lead- and zinc-mines the result would be satisfactory. They had seen one or two examples of work being carried out on a large scale by foreign companies, and it made him feel ashamed at their own lack of energy. The industry of lead-mining was practically dying out, and he hoped that the knowledge of the ancient history of these mines would result in mining-engineers throwing more energy into this branch of mining.

Mr. Luke Williams (Tasmania) said that Mr. Nall had told the members that the ore contained about 10 ounces of silver to the ton of lead, and as one greatly interested in lead- and silver-mines in the Colonies he would like to know the average width of the vein and the percentage of lead in the crude ore.

Mr. Harry Rhodes (Rotherham) asked whether Mr. Nall could give further information as to the occurrence of anthracite. It seemed curious to come across anthracite in the Alston district.

The Rev. W. Nall replied that three seams of coal were found in Alston moor, the two best seams being associated with the Little Limestone. The thickest was only 18 inches, and the other one only 12 inches in thickness. The coal was of a poor quality; it was used for lime-burning, but was not used in the cottages of the miners. It contained large quantities of sulphur.

The President (Sir Lindsay Wood, Bart.) said that as much as 80 per cent. of lead was found in some of the ore, and in others not more than 20 per cent. It varied very much in the veins and in different parts of the same vein.

Mr. Luke Williams asked what was the minimum quantity of lead profitable to work.

Mr. W. M. Egglestone (Stanhope) wrote that the historical part of Mr. Nall's paper on the Alston mines was very interesting, and gave one a glimpse of many lucky speculations in mining for lead-ore, and also of the contrivances for working the mines, the discoveries for extracting silver from the galena, with other events and incidents associated with a famous mining district seamed with metalliferous veins. In the geological part of the paper it was stated that—"The Tyne-bottom Limestone . . .

appears in the bed of the Tees near the source of that river and in the bed of Kilhope burn near Heathercleugh, and is in both these places underlaid by the Great Whin Sill."* A reference to the maps of the Geological Survey, or an examination of the exposed section of strata in the bed of Kilhope burn, near Heathercleugh, Weardale, would show that the Great Whin Sill here underlies the Single Post Limestone. This limestone in the section is a one-post stratum, 5 feet thick, and not at all like the Tyne-bottom Limestone, with its three flats and a thickness of 24 feet, less or more. Burtree-pasture mine, in the same neighbourhood, is now closed, but the section of the engine-shaft shows the same change of horizon of the Whin Sill—underneath the Single Post—to that assigned to it by Mr. Westgarth Forster, namely, underneath the Tyne-bottom Limestone.† He (Mr. Egglestone) had read a paper on the subject of the change of horizon of the Whin Sill at Stanhope, at a meeting of the Weardale Naturalists' Field Club in 1902.

Mr. J. Cameron Swan (Newcastle-upon-Tyne) wrote that Mr. Nall's interesting paper on "The Alston Mines" invited comment at some points of the story which he had so effectively told.

As regards the antiquity of the mines, there was no doubt that they were being worked at a period earlier, probably much earlier, than the date, 1131, at which authentic documentary evidence of their existence began, and they were mentioned in a manner which proved that the mines were then of great value, and must, therefore, have been in operation for the considerable period which (especially in those primitive times) would be necessary to bring them into the condition of such extensive and profitable working.

It had been stated with some confidence that the mines were worked by the Romans. They were on the spot, and the remains of the large station on the Maiden Way, at Castle-nook, 2 miles from Alston, were well known. But there was no direct authentic evidence that they raised lead in Tynedale. No Roman mining implements appear to have been found in old mine-workings, such as had, from time to time, been discovered in ancient mines in Spain and elsewhere.

* *Trans. Inst. M.E.*, 1902, vol. xxiv., page 399.

† *A Treatise on a Section of the Strata*, by Mr. Westgarth Forster, 1883, third edition, pages 61, 62 and 99; and Mr. D. Burns, *Trans. N.E. Inst.*, 1877, vol. xxvii., page 85.

He (Mr. Swan) might mention that one of the workmen at Nenthead told him that, when he was a washer-boy at Blagill mine, among the débris which came out of the ancient workings were the "antlers of deer, and fragments of rope made of leather." Blagill was the oldest of the more important mines at which some work had been carried on until present times. The leathern-ropes pointed to a date before the use of hemp for rope-making; and the deer's antlers pointed to the remote period when the hills were, to a great extent, covered with growing timber and were the natural habitat of herds of wild deer. It might be worth mentioning that the name of this very old mine confirmed Mr. Nall's statement that at a certain time the Alston mines were leased and worked by Germans, for "bla" was only a slight corruption of the German "blei" (lead), and Blagill is, in effect, Blei-gill or Lead-gill.

Mr. Nall mentioned that the leasing of the lead-mines to the Germans led to the diversion of the lead-trade from Carlisle to Newcastle. It also led to the naming of a portion of the old parish of Ryton, where there was anciently a lead-smelting works, and doubtless, in consequence of being made the place for the storage and accumulation of the lead from the west country, it acquired the name of Bleidon, or Blaydon, as we know it. Blaydon, it will be remembered, is the first point at which the Tyne becomes navigable for serviceable craft; and to this point came all the lead produced at the mines near the headwaters of the Derwent, Allen and Tyne, and at the extensive mines of Fallowfield, near Hexham. Thence it passed to "keels," and was carried by them down the river for treatment at Newcastle factories, or for shipment oversea.

The mine of "Fletchers at Gerrard's Gill," mentioned by Mr. Nall as having been granted by King Edward IV. in 1475, to his brother, the Duke of Gloucester and to the Earl of Northumberland, was no doubt the mine, in the Tyne valley, that we know as Fletcheress, and Gerrard's Gill, is, of course, our modern Garrigill.

The definite manner in which, in ancient leases and other documents, the mines of Alston are spoken of as "the silver-mines," appears to indicate that the mines we know were richer in silver when worked in the upper strata, or that there were other mines with which we are unacquainted, the ores from which contained a higher percentage of this metal than does the mineral

obtained from existing workings. The lead-ore now produced in the Alston district is not rich in silver. The average of Nenthead and of Weardale lead-ores is only about 7 to 8 ounces per ton of pig-lead. The ore of Greenhurth mine, in Upper Teesdale, and of Cashwell mine, at Crossfell, contains 10 to 13 ounces per ton of lead. The richest lead-ore that he (Mr. Swan) ever obtained from the Nenthead mines showed 16 ounces to the ton of lead, and this was produced from a very narrow string connected with the Rampgill vein. The ore, of which very large quantities have been raised, from the flats on and between the parallel north-and-south veins, known as the Great Cross vein and Smallcleugh Cross vein, contains no silver.

At one time, there must have been in the district, if not immediately at Alston, mineral very much richer in silver. Even so recently as the beginning of last century, some of the mines (Thortergill mine and Nentsbury mine, for instance) were yielding ore containing 21 ounces of silver to the ton of lead. And from time to time, pieces of "float-ore" have been picked up at or near the surface, and in the beds of water-courses, which have given high percentages of silver, some as much as 120 ounces to the ton of lead. One large boulder of ore, which weighed 2 cwts., contained over 90 ounces of silver to the ton. Close search was made for the lode from which this splendid mass of ore might have been derived, but it has never been discovered.

The exhaustion of many mines, and the reduction of the values of both lead and silver, have so unfavourably affected mining in the Alston district, that, but for one fortunate circumstance, it is not improbable that this ancient and useful industry would have nearly reached the point of extinction. At this moment, when the prices of lead and of silver have fallen so low, there has arisen a demand for zinc, which has made the ores of that metal of substantial value. And blende or "black-jack," which was worse than useless, and an actual source of trouble and of loss to the miner, has proved, for the time being at any rate, the salvation of the industry. For the Alston mines, or many of them, are rich in sulphide of zinc, and with the transfer which Mr. Nall chronicles from the London Lead Company to the Nenthead and Tynedale Lead and Zinc Company, a fresh chapter, which is of some interest, was opened in the history of the mines.

The mines were taken over from the London Company with

the object of working the zinc-ores on the property, in order to furnish supplies to the zinc-works at Tindale Fell. These works were originally built by Mr. James Henry Attwood, one of the brothers of a famous and very able family, of whom the best known in the north was Mr. Charles Attwood, the founder of the Weardale Iron-works.

The perception of the fact that there was a future for zinc, and the selection of the site for the works, was evidence of the acumen and remarkable judgment of Mr. Attwood. He had all Britain to choose from, and he certainly managed to make choice of the one spot in which the greatest number of favourable conditions were present. On the death of Mr. Attwood, the works passed into the hands of the company which eventually purchased the Alston mining properties of the London Lead Company.

The Nenthead and Tynedale Lead and Zinc Company immediately commenced the active development and working of the deposits of blende in the Nenthead mines, with results which gave a fresh lease of life to the mining industry. The importance of this change in operations will be noted in the following figures of production. In the last year of the London Lead Company's working, the zinc-ore raised was about 1,500 tons. In the first and subsequent years of the Nenthead and Tynedale Lead and Zinc Company's operations, the quantities raised were as follows:—1883, 2,275 tons; 1884, 2,650 tons; 1885, 3,034 tons; 1886, 3,117 tons; 1887, 3,205 tons; 1888, 3,820 tons; 1889, 4,010 tons; 1890, 3,830 tons; 1891, 3,940 tons; 1892, 5,208 tons; 1893, 5,378 tons; 1894, 5,449 tons; and 1895, 5,550 tons.

At this latter date, the lease of the land on which the zinc-works were built having expired; it was found impossible to obtain a renewal of the lease on practicable terms, and the mines were sold to the Vieille Montagne Company, Liége. The ore is now conveyed to their smelting-works on the Continent, and so the very interesting and serviceable work of the manufacture of metallic zinc came to an end in the North of England. The Belgian company (the largest makers of zinc in the world) being wealthy and enterprising, have continued to develop and to extend largely the workings for zinc-ore, so that the produce of blende from the Nenthead mines for the year 1902 was about 8,000 tons. The Company have leased the mines in the adjoining valley of West

Allen, and are raising there also large quantities of zinc-ore. These mines were standing, and owe their resuscitation entirely to the blende that they contain, the lodes being for the most part the same as those on the Nenthead side of the hill. The number of persons at present employed in and about the mines by the Vieille Montagne Company is upwards of 300, and the money disbursed, about £40,000 per annum.

The utilization of the ores of zinc has, therefore, made a complete and most welcome change in the present condition of mining in the Alston district. But the question which seems by far the most interesting and the most important, both from a scientific and economic point of view, concerns the future of these mines. Mr. Nall says that "every stratum between the Grindstone Sill and the Whin Sill has been pierced by the lead-miner in his search for ore." This is no doubt, speaking generally, correct, and the problem to be solved, and on the solution of which depends the future of metalliferous mining in Alston moor, is, whether the strata below the Whin Sill, say, down to and including the Melmerby Scar Limestone, will prove to be ore-bearing or not? Looking at the section with its strong beds of limestone and hazle and comparatively small intermixture of plate, it does not seem unreasonable to expect that veins in these lower strata should be productive. It must be owned that the general opinion of mining-engineers is not, on the whole, favourable as to the results of the deeper mining. But those directing the operations in the Alston mines for the Vieille Montagne Company, hold strongly to an opposite opinion, and affirm their conviction that mines will be opened in the lower strata as rich as any that have ever been worked nearer the surface. This is the all-important, the truly vital, question for the future of this wonderful old mining field.

Up to the present, there does not appear to be sufficient authentic information on which to base an opinion which might be expressed with confidence. In but very few places in the district has work been done below the Whin Sill. A few mines have been worked with some success in the Whin Sill itself. At Rodderup, west of Alston, where the Whin Sill is 180 feet thick, there is a good mine in it. But below the Whin Sill, where some not extensive work was done, the vein proved poor. At Burtree-pasture and on the Slitt vein to the east of Alston, some trials were made under the Whin Sill, with fair results at the Slitt mine and

rather poor at Burtree-pasture mine. At Greenhurth mine, in Upper Teesdale south of Alston, the Whin Sill was proved 240 feet thick, the vein carried ore all the way down; but nothing was done below the Whin Sill, as, when the bottom was reached, the water was found in such quantity as to drown the mine. At Settlingstones mine, north of Alston, and on the north of the Tyne river, the Whin Sill is 168 feet thick. The lode of carbonate of baryta carried ore through the Whin Sill. The workings are now 120 feet below the Whin Sill on the down cheek, and the lode is here as pure and productive as it has ever been in the upper strata.

The Vieille Montagne Company are engaged in proving the lower beds by an important sinking which they are making on Rampgill vein. They are already about 300 feet below what has hitherto been known as Rampgill low-level. At their last proof, by cross-cutting from the shaft at the Three-yards Limestone, the vein carried good lead-ore. A certain importance is attached to this trial, as it is immediately below the very heavy plate known as the Eleven-fathoms Plate. There was no ore whatever in the lode in the plate; in the Natrassgill Hazle, above the plate, zinc-ore was present, and in the limestone, below the plate, galena was found alone. It is intended to sink down to and prove all the strata to the Melmerby Scar Limestone.

The Rev. W. Nall said that the lead-industry of Alston—if he might apply the term "industry" to the process of picking out pieces of lead-ore from the bed of the Tyne and its tributary streams—was probably as old as the Roman occupation of that district. Lead-mining appeared to have been in a prosperous condition under the Plantagenet and Tudor kings of England, but it declined under the Stuarts. It revived in the reign of George I., and was very prosperous throughout the reigns of the four succeeding kings and the first decade of the reign of Queen Victoria. Speculation upon the future of lead-mining in Alston moor or in any of their northern dales would be an unprofitable exercise. The mineral-resources of the world were being rapidly developed; lead-ore was now being obtained from foreign countries in large quantities and at low rates. The carriage of lead from over-sea to Newcastle cost little more than the carriage from Alston, Teesdale or Weardale. But, while it was well to recognize these

facts, we should not despair of making further discoveries in the unexplored portions of our mineral-veins, and we might reckon among the possibilities of the future the utilization of the contents of the Great Sulphur vein. Let us hope that in the meantime the demand for blende, limestone, and crow coal might not only be maintained, but increased. Why should we not indulge the hope that, as in the past, a long period of depression was followed by a period of great prosperity, so in the future—near or remote—the present depression would be succeeded by a revival in the staple industry of the northern dales.

The PRESIDENT (Sir Lindsay Wood, Bart.) said there was no doubt that the fall in the price of lead was one of the greatest drawbacks to the working of lead-mines in this country. Spanish and other mines were worked entirely for silver, lead being a bye-product, and being sent over to this country practically as ballast. He had pleasure in moving a vote of thanks to Mr. Nall for his interesting paper.

Mr. M. WALTON BROWN seconded the resolution, which was cordially approved.

A paper was read by Mr. H. HUMPHRIS on the "Driving of an Inclined Tunnel 496 yards long and a Tunnel 842 yards long, and a Description of a New Method of Slate-quarrying in North Wales."

The PRESIDENT (Sir Lindsay Wood, Bart.) moved a vote of thanks to Mr. Humphris for his paper.

The resolution was cordially approved.

Mr. LOUIS P. BOWLER'S "Notes on the Gold Coast of West Africa" were read as follows:-

NOTES ON THE GOLD COAST OF WEST AFRICA.

By LOUIS P. BOWLER.

The writer's investigations have extended over an area, 60 miles inland and 100 miles along the coast, taking the town of Axim as a centre, and as far north as Bonsa river and Tumento, thence in a line to Essuasu on the Tarkwa-Sekondi railway, thence to Mansu and the Disc Cove district as the eastern portion, and Appollonia, Tano river and the Ivory Coast as the western portion.

The country is dotted with shallow shafts and native pits, and of the latter there are thousands, some old and some modern. The old workings are shown in the indents, or basin-shaped hollows, carrying trees of large girth and great age. The modern shafts are indicated by the absence of overgrowth and weather-wornness; and, of the latter, it must not be thought that all these workings are for gold, or indicate the existence of gold-reefs. The wily native requires no teaching how to salt a mine, or how to make a glowing statement by emphasizing the fact that his property possesses old native workings. Cunning to the utmost, he knows that by dotting his property with small holes, they pass as native workings, and add to the value of his estate.

But apart from these latter-day holes there are, without doubt, indelible signs of the vast industry of the ancient gold-workers, whose diligence was boundless, and whose knowledge of the value of the numerous outcrops was unrivalled.

The general formation of the country lends itself to primitive methods of mining, and to the easy extraction of the gold from oxidized bands of quartz lying in a clay-slate formation, and from alluvial deposits in the valleys and rivers.

The surface of the country is entirely covered with alluvial or drift-deposits, principally derived from the fractured and weatherworn quartz-veins and lodes that intersect the strata.

An examination of the outcrops of the lodes show that a large proportion have been tilted at various angles from what was

probably their original horizontal position. These beds are composed of semi-solid layers of quartz, resting on clay-slates and sandstones.

The quartz shows a mass of fractured pieces, cemented together and encased in silica. This "quartz-conglomerate" is common throughout the district visited by the writer. In some places it is of a bluish tinge with red oxidized stains, mixed with white silica; in other places, it consists of dark brown, oxidized matter, and dull whitish quartz stained yellow, and in others it is a black stained quartz. These auriferous beds occur in chloritic schists and diorites in some districts.

Many of these layers of detrital matter lie in geological sequence; and it would appear that they were formed during successive periods of dynamical disturbance, during which sedimentary deposits were spread over basins or planes then lying in horizontal positions. Later, these beds were disturbed by upheavals and tilted at high angles, together with the enclosing slates and sandstones. This action, being long-continued, has produced an enormous number of thin beds of alluvium and quartz.

The ancient workings are invariably sunk on the soft oxidized outcrop of the reef; and, where gold was found, the miles of old workings, in a line on one side of the outcrops, showed that the leader had been assiduously followed. There is no doubt that, with their primitive tools, the ancient miners pursued a ready method for the extraction of the gold, which they found in the soft oxidized portions of the reef.

In relation to these surface-beds, it would be interesting to solve the question as to what becomes of them in depth. The writer is of opinion that eventually they will be found to form part of a compact quartz-formation.

Mr. Edward Halse (London) wrote that Mr. Bowler spoke of the lodes or beds being composed of semi-solid layers of quartz, he would like to ask for an explanation of the term "semi-solid" as used here. In the following paragraph, the quartz-conglomerate is said to be a mass of fractured pieces of quartz "cemented together and encased in silica,"* and this also seems to

* *Trans. Inst. M.E.*, 1902, vol. xxiv., page 414.

demand an explanatory foot-note. He (Mr. Bowler) also stated that upheaval "long continued, has produced an enormous number of thin beds of alluvium and quartz."* Here there seems to be a confounding of cause and effect, as the alluvial deposits have undoubtedly been upheaved to a certain extent, but they clearly existed before that action and could not have been produced by it. The opinion expressed by Mr. Bowler in the last paragraph was simply pure conjecture, it was not based on any known facts, and did not help us at all in our knowledge of the West African auriferous seams.

Mr. T. B. F. Sam (Cape Coast Castle) wrote that a few remarks enumerating the methods of mine-salting adopted here, might be of great use to the members:—(*a*) Gold (dust and alluvial) is obtainable in the country, and it is nothing new to receive a sample full of nuggetty gold, which is easily detected by carefully separating the dust of the sample from the rock. (*b*) Pottery or firm clay is used to form an admixture with the gold with which the cavities in the quartz are filled, where the dust is absent; and it is detected by crushing the quartz a second time. (*c*) Melted gold had been detected in a sample by the use of a lens. (*d*) Small pieces of gold had been cleverly inserted in crevices of quartz. (*e*) Guns had been charged with gold and fired against the face of a reef, producing specimens, which a true expert could easily detect as fraudulent. These faults have been brought about by the boom producing many eager gold-brokers, who without expert knowledge take every piece of quartz from anywhere as gold-bearing, being even so mischievous as to produce samples of decomposed granite to the equally inexperienced purchaser, and no samples thus obtained should command definite plans.

Evidences of alluvial gold-mining in the country, being of ancient origin, is more apparent the further inland one goes; and by the prehistoric gads or drills picked up from the seaboard to nearly 170 miles inland.

The absence of gold in the quartz of the banket formation shows how much the granite (the bed-rock of the country) had been penetrated with strings of barren quartz, showing that there are only a few main gold-bearing quartz reefs, which easily yield their gold-contents, impregnating the pebble-bed together with

* *Trans. Inst. M.E.*, 1902, vol. xxiv., page 414.

the oxide of iron and sand binding them; clay slate being the recent sediment, the colour of which, dark ash, evidences that the graphite from the west and its gold-contents have played a great part.

The PRESIDENT (Sir Lindsay Wood, Bart.) moved a vote of thanks to Mr. Bowler, and stated that the members were greatly indebted to colonial members for many valuable papers.

Mr. M. WALTON BROWN seconded the resolution, which was cordially approved.

DISCUSSION ON MR. A. R. SAWYER'S PAPER ON "THE TARKWA GOLD-FIELD, WEST AFRICA."*

Mr. EDWARD HALSE (London) wrote that Mr. A. R. Sawyer, in his valuable paper, stated that "it is difficult to state definitely whether there are several reefs in this gold-field or not,"† but he described two as occurring at Teberibi. He (Mr. Halse), about 12 years ago, endeavoured to show that two reefs, or rather seams, occur at Tarkwa,‡ while at Abosso four seams had at that time been identified, and in the section of the Wassau mine, given in Prof. Henry Louis' edition of Mr. John Arthur Phillips' *Treatise on Ore-deposits*, four reefs are shown, or three conglomerate-beds and one of quartzose sandstone.‖ Two of the former, however, are close together, and probably form a portion of one and the same reef. He (Mr. Halse) believed that there is a series of conglomerate-beds in the Tarkwa district, but how many of these will eventually prove to be auriferous, is, of course, another question. Mr. Sawyer described the ore present in the matrix of the conglomerate as hæmatite. The latter word was evidently used in a general sense, for, in reality various oxides of iron are present, not only in the "cement," but also in layers in the sandstone among others ilmenite or titaniferous iron, and magnetite may be mentioned—indeed the term "black sand" would perhaps not inaptly describe the occurrence. There is little doubt but that the gold found in the striped sandstone and conglomerates is of alluvial origin, and this may account for iron-pyrites not having been found in depth. To whatever age the West African conglomerates may be assign-

* *Trans. Inst. M.E.*, 1901, vol. xxii., page 402; and 1902, vol. xxiii., page 527.

† *Ibid.*, vol. xxii., page 414. ‡ *Ibid.*, 1890, vol. ii., page 71. ‖ Page 730.

able—and they are not unlikely to prove to be much more recent than Mr. Sawyer supposed—a careful study of them will doubtless throw considerable light on the genesis of the gold in those of South Africa.

DISCUSSION OF MR. F. W. PAYNE'S PAPER ON "GOLD-DREDGING IN OTAGO, NEW ZEALAND."*

Mr. F. W. PAYNE (Dunedin, New Zealand) wrote that since writing his paper he had had further opportunities of testing the centrifugal elevators† in different classes of wash, and found that they work almost equally well with fine as with coarse gravel, stone of ¼ cubic inch and less being thrown on to the tailings-stack. The wind exercises some slight influence on such small particles, but as this is as likely, in an average locality, to be in favour of, as often as against, the throwing of the stuff, it is not of serious moment. He found, as would naturally be expected, that it was a great advantage to supply the tailings to the machine as free from water as possible, as the water not only was a serious additional load on the machine but, when converted into a spray by the beaters, created a dense medium for the stones to pass through, and in the case of fine stuff the retardation was apparent As, however, it was recognized to be a source of loss of gold where the water was thus allowed to pass through the screen, and was also easily remedied, this did not offer any obstacle to the adoption of the elevator.

He was aware of the method of operating a dredge by a pilot-house on American dredges, and it might possibly have advantages in the localities where it was used. In New Zealand, the success or failure of many claims depends upon cleaning the actual bottom, and to do this effectually constant inspection of the buckets is required as they come up, and with New Zealand arrangements, the winch-man stands on the deck-level and regulates the depth of dredging from there. From the time when he alters the angle of the ladder to the time when he can observe the effect of his alteration the buckets have to travel from the bottom to the deck-line, but if he was in the pilot-house above the top-tumbler, the whole length of buckets from the bottom-tumbler to the top would have to pass before he could see what effect his every movement on the

* *Trans. Inst. M.E.*, 1902, vol. xxiii., page 532.

† *Ibid.*, vol. xxiii., page 538.

winch had made. Two men were employed on Otago dredges: one to look after the fire, and the engine and machinery, and the other to mind the winch exclusively; and he could tell exactly how the dredge was situated by marks on his ropes, through the night as well as in the day, and could stop the buckets by a clutch operated from the winch at any time. He could not see that the placing him in an elevated pilot-house would be of any assistance to him, and in some respects, as already noted, it would put him at a serious disadvantage.

DISCUSSION OF MR. FRED C. KEIGHLEY'S PAPER ON "COKE-MAKING AT THE OLIVER COKE-WORKS."*

Mr. Fred C. Keighley (Uniontown, Pennsylvania) wrote that in making the statement that the Oliver coke-works were the second largest in the world (excepting the plant of Messrs. Jones & Laughlin at Pittsburg at that time under construction) he certainly had in view beehive oven-plants only. Since the paper was written, 100 additional coke-ovens have been added to the Oliver coke-plants, making a total number of 808 coke-ovens.

He agreed with Mr. Greener in the matter of oven-spacing; he believed that 6 inches between oven and oven was little enough to allow for expansion; and he thought that part of the excessive repair-cost was due to the fact that the space between the ovens was insufficient. With Mr. Greener, he also agreed in the belief that the larger the oven the more costly the repairs, but he thought that this was in a measure offset by increased capacity.

It would appear that Mr. Greener had misunderstood that part of the paper which referred to the materials used in construction. He stated that "it was a mistake to use cement or lime in the erection of coke-ovens, as the latter acted as a flux and destroyed the bricks," etc.† If Mr. Greener would refer to the paper, he would find that he (Mr. Keighley) stated that "the brickwork was all laid in loam-mortar, without admixture of lime or cement."‡ Their experience in the Connellsville coke-region was that loam is better than fire-clay for laying the brickwork of the ovens; and it is important to see that the loam does not carry iron. It is possible that the loam of this district is a superior article. They

* *Trans. Inst. M.E.*, 1901, vol. xxii., page 493; 1902, vol. xxiii., page 485; and 1902, vol. xxiv., page 158.

† *Ibid.*, vol. xxiii., page 486. ‡ *Ibid.*, vol. xxii., page 495.

had had little or no trouble with stone-work, where lime or cement was used, excepting that the cement was apt to crumble out in damp portions that were exposed to the action of very cold weather—this, however, had not affected the walls very seriously. He would not think of using either lime or cement-mortar in connection with the brickwork of the oven itself.

As Mr. Greener anticipated, they did not draw the ovens solidly but alternately, having in view the advantages to be derived from the proximity of a hot oven. He (Mr. Keighley) realized that there is a great waste of gases under the present practice, but the Connellsville coke-region is not yet in a position to take up the bye-product question. The larries are so arranged that the coal runs from either side, as may be desired.

He had experienced no great difficulty in burning either 24, 48, 72 or 96 hours coke; but, the very best results were obtained from the 48 hours burning. He had made thousands of tons of 24 hours coke in one month; and found no difference in the quality of the coke, excepting that it was much shorter in length than the longer burnings produced; but it would be well to say in that connection that the success in making 24 hours coke depends largely upon quick work.

He (Mr. Keighley) took no stock in the theory (which Mr. Greener quoted and also deprecated) that in order to obtain coke in the best possible mechanical condition, it should be allowed, as coke-burners describe it, "to soak in the oven" for 6 or 7 hours after it was burnt off.* He found, by actual experiment, that the standing over of a charge after it had been burnt off resulted in loss or wasting of the coke—a period of 10 hours showing a loss of 5 per cent. in weight. In the matter of breeze, which in their practice amounted to about 3 per cent., he might state that this was due largely to the large spaced coke-fork used in the Connellsville region, the space between the tines being $1\frac{1}{2}$ inches. Forks had been tried with $\frac{3}{4}$ inch tines, but the coke-consumer objected to the increased quantity of small coke resulting therefrom.

As everything in the way of drawing and loading was done by hand, no great reduction in the cost of production could be expected, even in new plants. The cost of labour in the Connellsville coke-region was continually on the increase, and no reduction in labour-costs could be obtained without the introduction of

* *Trans. Inst. M.E.*, 1902, vol. xxiii., page 488.

machinery in the drawing and loading operations, and this, so far as relates to the Connellsville coke-region, was still in an experimental stage.

The great thickness of the seam admitted of comparatively cheap mining; yet this cost was also on the increase, as that work was also hand-work, and so far machines had not been successful in the Connellsville seam.

Mr. T. E. Forster read the following paper on the "Under-sea Coal of the Northumberland Coast": —

UNDERSEA COAL OF THE NORTHUMBERLAND COAST.

By T. E. FORSTER.

Introduction.—The Northumberland coal-field extends along the southern portion of the Northumberland coast, from the Coquet to the Tyne, a distance of about 24 miles (Fig. 1, Plate X.).

Roughly speaking, the direction of the general dip of the measures is a little to the south of east, the line of outcrop commencing on the north at the mouth of the river Coquet, and running thence south-west by south.

This direction of the dip may be said to continue over the whole of the field, until a line is reached, eastward of which the beds commence to rise in a south-easterly direction. The course of this syncline is north by east, and nearly at right angles to the direction of the general line of dip. The northern end of the syncline passes under the sea near the river Wansbeck, and the southern end runs beyond the river Tyne, into the county of Durham, between Wallsend and Walker.

The average rate of dip is very moderate, and the field is not troubled by heavy faulting. With the exception of two large faults near the mouth of the river Coquet, the Wansbeck fault, and the ninety-fathoms dyke at the southern end of the field, near the river Tyne, all with an east-and-west course, there are no faults of unusual magnitude.

Coal-seams.—The upper series of seams, which have been chiefly worked in the eastern portion of the field, along the seaboard, are, the High Main, Grey or Main Coal, Yard Seam and Low Main. The lower seams, consisting of the Beaumont, Busty and Brockwell, have only been opened up to a limited extent, but will doubtless come into working on a much more extended scale as they are required. The vertical distance from the High Main to the Brockwell seam is about 750 feet.

The extreme northern part of the field, in the vicinity of the river Coquet, appears to be occupied chiefly by the lower seams, but it has never yet been possible to correlate them exactly with the seams of the district to the south. Between the two portions of the field, there is a belt of ground, the exploration of which has not so far yielded satisfactory results. Such proofs as have been made, point to alterations in the character, not only of the coal-seams, but also of the beds associated with them, and the fact that the lower seams near the Coquet bear no resemblance to those occupying the ground to the south, forms a barrier to their complete identification, which will probably never be entirely removed.

The principal seams of the Coquet district are:—The Radcliffe, Albert, Queen, Princess, Duke and Yard seams, which are found in a vertical distance of about 400 feet. The Radcliffe seam is supposed by some to be the Low Main, and the Princess, the Beaumont of the Blyth and Tyne district, but, apparently, this is a mere speculation.

The following is a brief description of the conditions under which the various seams exist along the coast-line. Commencing at the mouth of the river Tyne, and passing northward, to Seaton Sluice, the measures, owing to the synclinal axis above mentioned, have a south-easterly or seaward rise; and, consequently, the upper seams crop out practically along the coast-line. The lower seams have never been worked in this vicinity, but probably extend seaward for some distance under a workable thickness of cover. The trend of the coast, passing northward, is to the west of north: and, consequently, the synclinal axis approaches the shore-line and the seams along it assume a heavier cover. The section (Fig. 2, Plate X.), from Hartley, past Seaton Sluice and Blyth, through Newbiggin and northward to the mouth of the river Lyne, is intended to shew approximately the position of the beds along this section of the coast.

Along the southern part of the line, the cover is gradually increasing, as the line of the section approaches nearer to the synclinal axis, the Low Main, off the mouth of the river Blyth, lying at a depth of about 400 feet below sea-level, 600 feet at Cambois, with a further dip of about 150 feet to Newbiggin bay, where the large downthrow-fault to the north, known as the Wansbeck fault, is found. North of this the beds rise very rapidly, until

they pass beyond the region of the fold caused by the fault, and regain their normal level and rate of dip. Beyond the Wansbeck fault, they are, however, unexplored along the coast-line, and that portion of the section is compiled from such information as can be got from data obtained slightly further inland. The belt of doubtful ground described above, commences north of the river Lyne, passes Cresswell and stretches into Druridge bay.

Half-way up Druridge bay, at the mouth of the Chibburn, the Coquet district of the coal-field may be said to commence with the southern limit of the workings of Broomhill colliery, abutting on an east-and-west fault. Beyond this, the seams lie regularly for a considerable distance along the shore-line, with a gentle inclination to the east, until they come within the line of influence of the first of the two great faults previously mentioned, towards which they dip heavily. This fault is computed to throw up the beds, 480 feet, to the north; and the second fault (met with about ¾ mile farther on) has a throw of about 600 feet in the same direction. Beyond this, the beds rise to their natural outcrop north of the mouth of the river Coquet.

Coast-line.—So far as surface-features go, the coast-line consists of a series of rocky points, alternating with long bays, the shores of which are occupied by hills of blown sand, capping the Boulder-clay, which, generally speaking, covers the whole of the low-lying flat-country in the immediate neighbourhood of the coast.

The promontories usually mark the lines of east-and-west faults, against which the clay generally attains its greatest thickness, thinning gradually in the direction of the rise of the underlying measures (Fig. 2, Plate X.).

At Cambois pit, the clay is upwards of 80 feet thick, gradually decreasing southward to North Blyth rocks, and re-appearing on the southern side of the river, where it lies, about 60 feet in depth, against the cheek of the fault, which forms the northern side of the entrance-channel to Blyth Harbour and thinning again along Blyth Bay to Seaton Sluice.

The bed of the sea may be described as shelving gradually eastward. The different submarine contour-lines have a regular and uniform course: the variations in their distance from the shore, being due almost entirely to irregularities in the coast-line.

The average distance of the 50 feet line of soundings from high-water mark may be taken at about 1 mile, and that of the 100 and 150 feet lines at about 2 and 4 miles respectively. Except in the vicinity of the promontories, the sea-bottom is apparently entirely covered with sand, and the distance to which the clay found along the shore-line extends seaward is altogether unknown and is likely to remain so.

The fact that the distance to which the clay-capping extends seaward is unknown, together with its liability to be thrown out by faults, unfortunately renders it imprudent to take it into consideration as an important factor of safety in fixing the limit of cover for comparatively shallow workings.

The strata, comprising the Coal-measures, consist of ordinary beds of sandstone and shale, with thin beds of fire-clay, generally forming the thill or floor of the coal-seams. The sandstones, or "posts," are usually somewhat open in nature, and generally pass water freely; the shales, or "metals," are closer and more water-tight; while the clays are still more impervious to water. The district is by no means heavily watered; and, as a rule, a great part of the expense consequent on drainage is due to the difficulty of concentrating the underground feeders through the undulating nature of the beds, rather than to the actual quantity of water to be raised to the surface.

The average composition of the strata overlying the Low Main seam at the North Seaton, Cambois and Cowpen collieries is as follows: —

	North Seaton. Per Cent.	Cambois. Per Cent.	Cowpen. Per Cent.
Sandstones	42·17	56·64	45·34
Shales, and shales with thin beds of sandstone	47·97	27·31	40·86
Coal-seams	4·78	4·25	3·73
Fire-clays	5·08	11·80	10·07

Undersea-workings.—The principal undersea-workings in the district are those which have been carried on for many years by the Cowpen Coal Company, Limited, a description of which may be of interest.

North Seaton Colliery.—The earliest undersea-workings were commenced from North Seaton colliery in 1872, in the Low Main seam. This seam lies at a depth of about 670 feet below sea-level

at high-water mark, and is 5 feet in thickness, with a fairly good roof. A barrier, 300 feet in width, was left near low-water mark, and in accordance with the requirements of the Crown agent, acting under the provisions contained in the Crown lease, pillars were left for the support of the overlying strata, amounting to about 40 per cent. of the seam.

In the first instance, an attempt was made to take out the whole of the 60 per cent. to be worked in one operation: pillars being formed 13½ feet wide, and 90 feet long, the bords being driven 18 feet wide and the walls 7 feet wide. It was found, however, that, after a certain amount of ground had been worked in this way, a creep came on, and the face was difficult to keep open.

Recourse was then had to larger pillars: the dimensions being fixed at 45 feet wide by 90 feet long, with 18 feet bords and 7 feet walls. After these had been carried forward some distance, the pillars were split by means of an 18 feet bordways split, the splitting being commenced at the inbye-end of each district and brought back in the same way exactly as in broken working. The result of this altered mode of working was that the creep was avoided, and the 60 per cent. of coal was successfully extracted.

The workings in this seam were carried seaward for a distance of about 1¼ miles from high-water mark, the seam seaward having a slight rise to the south-east, and a heavier dip to the north-west at the northern extremity of the workings. The workings have not been extended seaward since 1887, although a large quantity of coal has been extracted nearer to low-water mark; and, in this case, the seam has been worked on the ordinary bord-and-pillar system, and the pillars removed in the usual way.

A commencement has recently been made to work the overlying Yard seam under the sea, under a cover of 490 feet at high-water mark. The seam is about 2 feet 8 inches thick, with a good roof, and is worked entirely on the longwall system. The gateways are made 33 feet apart, and the spaces between them are carefully packed with stone. The face of these workings is now about ¼ mile from high-water mark, and the workings are lying entirely over the old workings of the Low Main seam, 180 feet below. No barrier is left in this seam between the land-coal and sea-coal.

The limit of cover, up to which the whole of the coal may be

extracted, is fixed at 270 feet, and provision is made in the lease for the exploration of the ground in advance of the longwall workings (after the area already explored in the Low Main seam has been worked over) by means of a drift to be carried seaward, 150 feet in advance of the face, in order to ascertain the position of any intersecting faults. It is further provided that 30 feet of coal, at least, shall be left against all faults having a throw of more than 30 feet, or of which the cheeks are more than 2 feet apart, although roads may be carried through such barriers where required in the ordinary course of working.

Cambois Colliery.—The working of the undersea coal at Cambois colliery was commenced in 1882, in the Low Main seam (about 4½ feet thick) and at a depth, at high-water mark, of about 576 feet. As at North Seaton colliery, it was at first required that 40 per cent. of the coal should be left, in the shape of small pillars. Considering the difficulty of working the small pillars, the great loss of coal caused by leaving them, and the depth beneath the sea-bed, it appeared to the lessees, that, provided proper precautions were taken, no danger could result from the total extraction of the coal up to a certain limit of cover. It was argued that, although large goaves had been formed for many years in the Low Main seam under the land-area worked by the company, and the Yard seam had subsequently been worked above these goaves, without any appearance of disturbance due to the working of the Low Main seam, and without the downward disappearance of any of the water of the Yard seam, it might reasonably be assumed that the intervening strata, 180 feet in thickness, would be sufficient to guard against feeders from above the level of the Yard seam being brought down to the Low Main seam, and that a further allowance would place any fear of disaster from the removal of the pillars of the Low Main seam beyond any reasonable doubt.

Application was then made to the Crown authorities, and permission was accorded to work out the whole of the coal lying under a cover of 360 feet, under certain conditions, the chief of which were as follows: —

1. In the case of longwall workings, the driving of exploring drifts 300 feet in advance of the actual workings, on the lines of the intended main roads.

2. In the case of bord-and-pillar workings, the provision of barriers, 150 feet thick, along the side of the main roads, and of 60 feet barriers along the "side," or branch, roads, with the idea of forming the workings into panels and isolating these panels, so as to enable any one of them to be dammed off in case of heavy feeders being met with.

3. The provision of barriers of coal, 60 feet wide along the sides of any faults met with, having a throw of 18 feet or upwards, or having cheeks, 2 feet apart or upwards.

These workings have since been carried on most successfully, and very large goaves have been formed under the bord-and-pillar system, without any packing or support being put in, and without any more water being met with than is usually the case under the land under similar conditions.

The winnings have been driven seaward for a distance of about 1½ miles from high-water mark, and have been stopped for some years owing to a splitting of the seam which, it is hoped, may prove local, and may eventually be passed through. The main winnings, to the east of the shaft, have risen slightly; and, presumably, are just on the eastern side of the synclinal axis which appears to run towards Newbiggin point.

Cowpen Colliery.—The working of the undersea coal, at Cowpen colliery, was commenced in the Low Main seam (about 4 feet thick), from the Mill pit in 1888. The ground worked to this pit is on the eastern side of the syncline, and the seams rise regularly to the south-east at a gradient of about 1 in 75. The winnings were driven seaward for a distance of about ¾ mile from high-water mark, when a disturbance, probably forming part of the one met with at Cambois colliery, was encountered. It is, however, hoped that this will be avoided by the winnings which are now being driven farther to the south, and below the fault at the mouth of the river Blyth.

This area is held under the same lease as the Cambois undersea coal, and the pillars have been removed in the ordinary way up to the 360 feet limit of cover prescribed by the licence varying the terms of the original lease. Permission to extend the total extraction of the seam, which is here about 3 feet thick, farther seaward, up to a limit of cover of 300 feet, has recently been given, provided that all workings between the 360 and 300 feet lines of cover, are made on the longwall system and are securely packed.

The remaining area to the south (Newsham), held by the company, is now being entered upon from the Mill pit in the Low Main seam. The seam is here 3 feet thick, and lies at a depth about 590 feet below high-water mark.

The foreshore here (as at Cambois) is the property of the adjacent landowner, and of considerable extent. Both the Yard seam (2¾ feet) and the Low Main (3 to 3¾ feet) have been entirely worked out under a great part of this area, the amount of cover over the Yard seam being only about 240 feet. The surface deposits were, however, capable of being proved by boring, and were found to consist of from 40 to 55 feet of Boulder-clay.

The limit of cover up to which the whole of the coal may be removed, under the Newsham lease, is fixed at 300 feet, and there are provisions for exploring in advance of longwall workings and leaving barriers against the main roads of any bord-and-pillar workings.

Broomhill Collieries.—The only other undersea-workings, which have been undertaken up to the present time, are those from the pits of the Broomhill Collieries Limited, in the district of the river Coquet.

At Newbrough colliery, winnings have been driven seaward in the Princess seam for a distance of about 2,400 feet from high-water mark. The cover at the last-named point is about 480 feet, the seam (2 feet 7 inches thick) is dipping seaward, and the cover at the face is about 420 feet thick.

About 1½ miles farther south, a commencement has been made to drive exploring places seaward in the Duke seam, near the southern extremity of the workings in that seam from Broomhill colliery. The cover here is about 240 feet thick, at present; and the seam is about 4 feet thick, and is being split into two portions by a gradually thickening band.

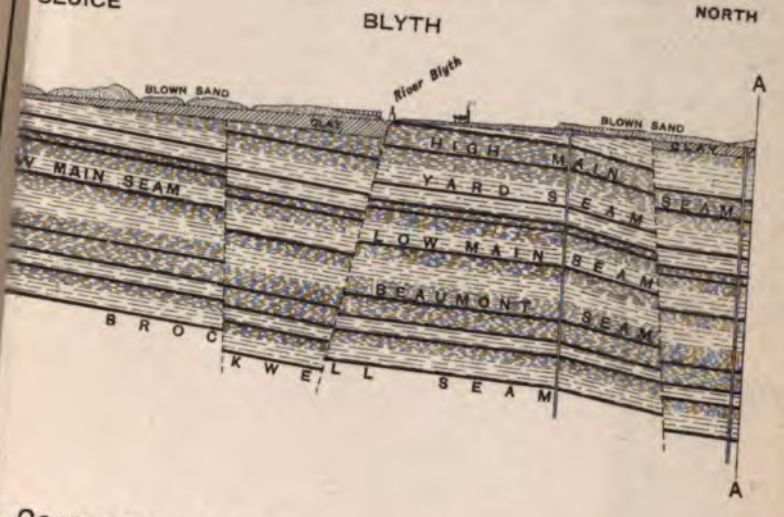
Unworked Areas.—It may here, perhaps, not be out of place to add some remarks as to the unworked portions of the field.

South of the Newsham area, towards Hartley, there will no doubt be coal, which will be found under a workable cover, consisting, probably, of a comparatively small tract of the Low Main seam and much more extended areas of the lower seams.

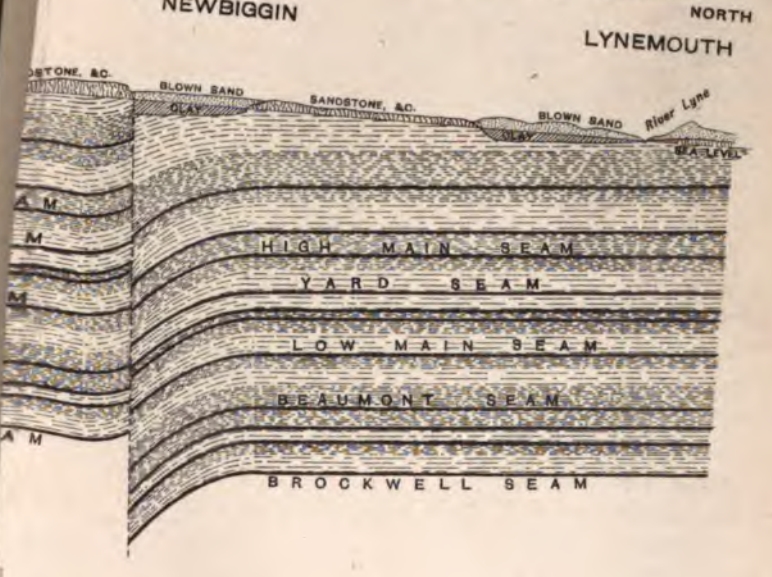
Possibly, from Hartley southward, the lower seams may from a further reserve of workable undersea coal.

FIG. 2.

THE COAST FROM HARTLEY TO LYNEMOUTH.



E COAST FROM HARTLEY TO LYNEMOUTH (CONTINUED).



Horizontal Scale, 1 Mile to 1 Inch.

Vertical Scale, 600 Feet to 1 Inch.

North of the river Wansbeck, the area of workable coal will, probably, depend chiefly on the exact course of the synclinal axis, and the farther it trends seaward, the greater will be the extension of the field in that direction.

It appears, however, to be possible that the easterly rise may not continue indefinitely seaward and that an anticline may be met with, which will still further prolong the extension of the field eastward. In any case, it seems certain that a very large reserve of coal is contained in the undersea area under consideration.

Conclusion.—In conclusion, it may be of interest to call attention to the fact that the operations, which have been described above, form a record of the progress which has been made, in this vicinity, in the working of coal lying at moderate depths under the sea. Experience has been gained since 1872, when it was considered necessary to leave unworked a large proportion of a seam with a cover of more than 600 feet, which has gradually admitted of the lowering of the limit to, in some instances, less than 300 feet, and has resulted in the working of large quantities of coal which it was at one time thought would be lost.

The writer hopes that the results of this experience may possibly be of use to others, although, at the same time, he would point out that a careful consideration of the local circumstances is of great value in fixing the conditions under which undersea operations are to be carried on.

Mr. J. G. Weeks (Bedlington) said that Mr. Forster's paper contained a clear and succinct account of under-sea workings, and it would be a valuable addition to the *Transactions*, as it dealt with every detail. The paper referred to the thinning out of the clay westward from the sea, until at a line between Bebside and Choppington stations it ran out, and the rock came next to the surface. He (Mr. Weeks) said that the line would run about 4 miles west from the sea-coast. The clay thinned away from 60 or 80 feet to practically nothing, and ordinary sandstone formed the surface with a soil-cover. Mr. Forster did not give the size of the Wansbeck fault; he (Mr. Weeks) had recently proved it, and was somewhat surprised to find that it amounted to 636 feet

at a point between the Bedlington and Ashington collieries, and he had proved it within 200 feet of the workings on either side.

Mr. T. Forster Brown (Cardiff) stated that Mr. Forster's paper appeared to form a complete record of the coal-workings under the sea in Northumberland so far as they had gone. He (Mr. Forster Brown), as the Crown chief mineral inspector, had inspected these workings, from time to time, and he thought it clear that a sound principle to begin with in working longwall in a seam under the sea, unless the depth was exceedingly great, was to have the whole of the space packed thoroughly, so as to avoid any question of endangering the coal, either under the land- or sea-workings. He would be glad if Mr. Forster would explain his grounds for supposing that there might be another anticlinal axis seaward, and beyond that there might be a dip seaward which might extend the coal-area. He entirely agreed with Mr. Forster that after all, in working an unknown area, where they had no surface to guide them, and could only obtain their knowledge and experience by underground operations, it became a question of circumstances, as time went on, how to deal with any particular difficulty that might arise under the sea.

Mr. H. M. Cadell (Grange, Bo'ness) said that he was interested to some extent in submarine mining in the Bo'ness coal-field, on the Firth of Forth, although the workings did not extend so far as those described in Mr. Forster's paper. He had previously communicated a paper upon the workings at Bridgeness colliery,* but since that paper was written the Main seam had cropped out towards the west against the sea-bottom at a depth of 500 feet. They did not experience any inconvenience, although they were at first a little alarmed and disappointed at striking the sea-bottom so soon. Several glaciated stones fell out, showing that they had got into Boulder-clay. The Firth of Forth was now only about 20 feet deep at that point, and there must have been a deep trough in former times, which had cut off the outcrop of the seams in that direction. Three or four seams were worked in the section, and they all cropped against the bottom of the Boulder-clay. The deepest place where this had been reached was 500 feet, and that was only ¼ mile below low-water mark. The centre of the Firth of Forth was an old valley eroded prin-

* *Trans. Inst. M.E.*, 1897, vol. xiv., page 237.

cipally during the Glacial period, and it was not probable that such a thing would be met with in this district, because these deep troughs were only found in places where there had been old river and valley-glaciers. It would be a useful thing at the extreme end of the workings to put a bore upwards to the bottom of the Boulder-clay in order to ascertain its depth, and the hole could be easily plugged. One part of the workings at Bridgeness struck the bottom at a depth of 170 feet, and the Boulder-clay being very strong formed such an excellent roof that the seam had been worked under it for many feet. A large glacial stone then rolled out and nearly killed a man, and the workings were thereupon stopped. He merely mentioned this as an example of how excellent a roof Boulder-clay could form. If it was possible to prove that the whole of the ground was formed of Boulder-clay, it would be quite safe to work out all the coal. One great advantage of submarine workings was that there was no surface-damage to pay for, and this often meant the difference between profit and loss at many collieries. Of course the farther out they went under the North Sea, the less would be the cost of surface-damage in proportion to the area of the workings. It was not likely that there would be much sand out at sea; the sediment from the shore was carried out as fine mud, and the farther seaward they got the roof should be all the tighter. He would like to know whether there was much water to contend with in the Northumberland workings; under the Firth of Forth, there was not; and down to a depth of 600 feet the water was so small in quantity that it could be dealt with by a Moore hydraulic pump with a ram 8 inches in diameter. The bed of overlying clay kept the workings remarkably watertight.

Mr. J. B. Atkinson (H.M. Inspector of Mines, Newcastle-upon-Tyne) said that there were two points to have in view:—(1) The danger of losing the workings by water, and (2) the danger of loss of life. The first danger would usually declare itself before the second, although that had not always been the case, as was shewn in the accident at the Workington collieries, where there was considerable loss of life from working the undersea coal. There were four factors to consider:—(1) The thickness of the coal-seam; (2) the thickness of the solid strata above the coal; (3) the thickness of the alluvium; and (4) the depth of water. Of these factors, only the thickness of coal and the depth of water were usually

ascertained. It was difficult to ascertain the proportion of alluvium and solid strata. Mr. Cadell's suggestion that a bore-hole might be put upward from below would test this proportion. Mr. Forster's paper was a useful contribution to the study of a question which would become more important in the near future, and it shewed clearly what had been done with safety.

Mr. J. GERRARD (H.M. Inspector of Mines, Manchester) offered for consideration an additional factor, which might be of interest; that was the nature of the strata overlying the seam of coal, the thickness of the beds of bind or shale, and the thickness of the beds of sandstone. In connection with questions of subsidence, much depended upon whether there were extremely thick beds of sandstone or moderately thick beds of shale or bind.

Mr. W. H. PICKERING (H.M. Inspector of Mines, Doncaster) hoped that Mr. Forster would supplement his paper by giving the conclusions at which he might have arrived as to the best method of working undersea. At Cambois colliery, the bord-and-pillar method was adopted and large goaves were formed, and he presumed that there would be heavy falls. At another pit, only long-wall was worked, and they built tight packing. This appeared on the face of it to be the safer condition, but without knowing all the circumstances one could not decide. The conclusions at which Mr. Forster might have arrived on the subject would be of interest.

Mr. R. E. ORNSBY (Seaton Delaval) said that it would no doubt be necessary at no very distant date for the adjoining colliery under his own charge that he should consider the question of undersea working. Unfortunately they were not so well placed as at Cowpen colliery, as the seams at Hartley colliery rose to the eastward. With respect to the strata between the Yard and Low Main seams, his experience was similar to that at Cowpen. The Yard seam to the dip was standing full of water, some pillars were wrought, about 200 feet below in the Low Main seam (with a thickness of 6 to 7 feet of coal), and although they were afraid of the water, they practically got none at all in the Low Main seam, notwithstanding that there were heavy falls in the goaf.

Mr. C. C. LEACH (Seghill) asked whether there were any bottom feeders, and, if so, were they salt?

The CHAIRMAN (Mr. J. S. Dixon) said that, in his own experience, he had dealt with workings not under the sea, but under inland waters and under wastes containing water; and as to the expediency of leaving a portion of the solid coal, his view was that the less coal they left the better, but that the waste should be thoroughly stowed or packed. In the part of the country with which he was connected, leaving in a piece of coal led to dislocations: and these ultimately came to the surface and created cracks through which water might percolate. With a cover of 70 or 80 feet of Boulder-clay, great liberties could be taken when working seams at moderate depths. In many cases, seams had been worked, 3 feet thick, under wastes lying full of water, 200 feet above, and through every break of the strata small feeders of water were got; but in the course of a few weeks these were filled up by the swelling of the fire-clay and shales, and the strata behind the face became impervious, whereas the strata at the face gave off a little water. Where there was mud in the bottom of a river, or even sand, this very often filled up the interstices made by the subsidence of the coal-working. If it could be proved by boring in the sea that the clay extended over the whole area of the coal-workings, he thought that probably the coal might be worked even nearer the surface than indicated by Mr. Forster.

Mr. H. R. HEWITT (H.M. Inspector of Mines, Derby) said that it appeared to him that longwall working in panels would be the preferable system of working coal-seams under the sea, where systematic packing, or the complete filling of the goaf could be carried on in the workings left behind the face. It seemed to be severely tempting providence to work by pillar-and-stall, where no packing is done, the pillar robbed, and large falls of roof of unknown height frequently occur. Although soundings are taken giving the depth of water, showing the amount of strata between the sea and the seam, yet there are seas with a shifting bottom, a circumstance which in the cases quoted, does not appear to have been taken into consideration. Whether the German Ocean at these points is one of that kind or not, he could not say, but if it is, the soundings are entirely unreliable.

Mr. M. W. PARRINGTON (Wearmouth Colliery) wrote that, if anything could have made Mr. Forster's paper more useful to those interested in the Great Northern coal-field, it would have

been its extension to the whole coast-line of the field from the mouth of the Coquet to Hartlepool; and he believed that no one had a better general knowledge than Mr. Forster of the conditions met with south of the Tyne. Perhaps, however, it would have been premature to have so extended it while the great coast-winnings at Dawdon, Easington and Horden are still incomplete. These winnings are far enough advanced to have proved the thickness of the Magnesian Limestone, and (by boring) the thickness of the underlying sand; and they show that the bottom of the sand has a generally increasing depth, below sea-level, to the south, as far as proved. It had also been proved, at very great cost to the proprietors of these winnings, that the sea had direct communication inland, through the limestone-fissures, and that it was only necessary to exhaust the fresh-water feeders to get sea-water, pure and simple. This communication will doubtless become more remote as the distance from the coast increases, but that it exists to some extent wherever the limestone is below sea-level seems proved by the fact that the surface of the water in the Magnesian Limestone will come to rest at or about that level. He (Mr. Parrington) had made these remarks with the view of showing that the workings of the deep east-coast collieries of Durham are practically, where not actually, under the sea.

He (Mr. Parrington) believed that in only one case had any considerable area of coal been worked at a less depth from the bottom of the Yellow Sand (where below sea-level) than those from the sea-bottom given by Mr. Forster, and, in that case, large areas of a 4 feet seam were extracted by a modified system of longwall at a depth varying from 330 feet to an estimated depth of 200 feet. Pillars were formed at the small estimated depth of between 40 and 50 feet; but when, under stress of circumstances, an ill-advised attempt was made to extract these pillars, the natural result followed.

Some of Mr. Forster's remarks point to the great desirability of a thorough examination of the sea-bed. It was difficult to believe that loose sand lies to any great depth on a sloping bottom; and, therefore, he (Mr. Parrington) ventured to think that, with proper appliances, samples of the original formation might be obtained at intervals along the coast, and to a distance of 2 miles out or even more. The cost, when divided among all parties interested, would not be very serious.

He hoped that Mr. Forster might be able, at no remote date, to supplement his valuable paper with one on the "Undersea Coal of the Durham Coast."

Mr. H. S. Poole (Halifax, Nova Scotia) wrote that in Nova Scotia a consideration of undersea workings elsewhere, the depth of rock-cover between the water and the workings under varied conditions required by regulations, the methods of operating, and the precautions taken against irruptions of water from the sea-bed, were matters of great interest, as in that province there are large coal-fields lying under the sea. These leases are held under conditions differing from those described by Mr. T. E. Forster, in his paper on the "Undersea Coal of the Northumberland Coast";* and in that of Mr. A. A. Atkinson on "Working Coal under the River Hunter, the Pacific Ocean and its Tidal Waters, near Newcastle, in the State of New South Wales."† No official in Nova Scotia is empowered to modify the terms of leases to suit local conditions, one set form being supplied and held applicable to all for a given period; and legislation regulates all restrictions. In all but a few early grants of land, the Crown reserved its rights to one or more of the economic minerals, issuing the grants as applied for without any pre-arranged plans. So it has been with the minerals reserved: applicants for rights to search or work, and for leases, exercised their choice of location within certain limits as they pleased, and without regard to the convenience of approach and general working, or the best interests of the whole coal-field. This system applied to all submarine as well as subterranean holdings.

The writer, when acting as an inspector of mines, foresaw that a time would come when special legislation for submarine operations would be necessary. In his report for 1877, he suggested precautionary measures, and, later on, he drafted the clauses relating to submarine areas incorporated in the Mines Regulation Act of the following session, and these have since then remained unchanged on the statutes. These regulations antedate by some eight years some of the recommendations of the New South Wales Commission of 1886, as follows:—"The Commission are fully aware that, so far as they know, no restrictions such as those indicated have been as yet considered necessary

* *Trans. Inst. M.E.*, 1902, vol. xxiv., page 421.

† *Ibid.*, 1902, vol. xxiii., page 622.

in Britain or her colonies."* The restrictions imposed, in 1877, in Nova Scotia, although not so exhaustive as those of New South Wales, met the requirements of the time. Workings below 500 feet of rock-cover are left untrammelled, all under a less cover are restricted, and those under less than 180 feet are totally debarred, except for approaches, which may be carried on with 100 feet of overlying strata. These figures have, somehow locally, become regarded as allowing so safe a margin that applications have been made to the Legislature to have them reduced on the plea that so much coal is locked up and lost, but so far without success.

Up to the present time, the only extensive operations under the sea have been made at the mouth of Sydney Harbour, in the Main seam, dipping 1 in 12. There, under a cover of 800 feet, pillars have been robbed, and longwall workings conducted where the depth was 1,000 feet, without the seepage of any salt-water. But at shallower depths, some had been found: the deepest at about 400 feet, where a steepening of the measures was approached, and a lype may have given access to a small feeder of sea-water. The Coal-measures of Cape Breton are for the most part sandstones in which open "backs" have been encountered.

The sinking of the Princess pit, 600 feet away from the cliffs, tapped a feeder of 400 gallons a minute, and this was tubbed back. Over the workings, the deepest soundings give about 40 feet of water with a sand-bottom, which may or may not overlie a deposit of till, but no attempt has been made to determine its presence. Mr. A. A. Atkinson referred to the condition of the Sydney mines workings some years ago.† Now, the dip-plane is 6,600 feet long, the distant submarine workings extending 3,400 feet from the point of Cranberry Head, where, at a depth of 1,000 feet, the pillars are increased in dimensions to 33 feet by 132 feet. The Sydney Main seam averages over 5 feet 3 inches and in parts is 6 feet thick, dipping 1 in 12 towards the open sea. The pillars to the deep have been successfully wrought, even in crushed districts.

In the overlying Lloyd's Cove seam, a dip-plane is now being driven beyond Cranberry Head, close within the permitted limit of cover. These operations are in the Cape Breton coal-field, which has a sea-front of 32 miles.

* *Trans. Inst. M.E.*, 1902, vol. xxiii., page 636.

† *Ibid.*, 1902, vol. xxiii., page 647.

On the western side of the island, the Coal-measures extend nearly 40 miles, but on parts of the coast Lower Carboniferous rocks come to the surface, and it is evident that the submarine portion of the Inverness coal-field is, although of importance, comparatively less extensive. The dip is steep from the shore under the waters of the Gulf of St. Lawrence, carrying the coal-seams rapidly beyond a working depth.

The very thorough investigation of the subject of operating coal-mines under water by the New South Wales Commission and the paper by Mr. A. A. Atkinson come opportunely for the conditions now under review in Nova Scotia, where off the coast of Cape Breton, there are large areas of thick coal-seams lying under light and moderate depth of cover, temptingly near the shore, and extending seaward for several miles. In parts undulating with low dips, the outcrops of the seams enter the sea and necessarily large districts of valuable coal will have to be sacrificed to considerations of safety. The question at issue is not at what depths working can be conducted without anxiety, or at what additional depth with confidence, but how thin may be the solid cover and how large may be the proportion removed. The rapidly growing coal-trade is already looking to these sea-areas for the speedy establishment of pits so laid out as ultimately to win the extreme limits that ventilation, mechanical appliances and competition-cost may permit. The New South Wales Commission advisedly places importance on the condition of the sea-bottom, the presence or not of clay; but off Cape Breton nothing is known beyond what the soundings have demonstrated the superficial covering to be, mud, sand or rock. In-shore, where the water is shallowest along the headlands exposed to the full force of easterly storms from the Atlantic Ocean, and to comparatively rapid erosion, there must be a broad strip of ground won by the sea since the close of the Glacial period, on which there may be no bed of clay such as that period left deposited over most of the land. In the work of erosion, the pounding of the sea has been assisted by the disintegrating effect of frost, and the removal of the débris by the shore-current, which flows strongly by from the north. Outside these strips, where no deposits of Glacial drift were left, there is in places no doubt a protective mantle of clay.

The following are the regulations as to working submarine areas:—

52. (1) In the working of coal or stratified deposits in submarine areas, the following provisions shall apply:—

(*a*) No submarine seam of coal or stratified deposit shall be wrought under a less cover than 180 feet of solid measures: provided that the owner or lessee of any such area may drive passage-ways, to win the mineral to be wrought, under a less cover than 180 feet, but not under less than 100 feet of solid measures;

(*b*) A barrier of the mineral wrought, of not less than 50 yards, 25 yards on both sides of the boundary-lines of every lease, shall be left unwrought between the workings of every submarine seam;

(*c*) Where there is less than 500 feet of solid measures overlying the seam or stratified deposit wrought, the workings of every such submarine area shall be laid off in districts of an area not greater than ½ square mile, and the barrier enclosing each separate district shall not be less than 30 yards thick, and shall not be pierced by more than three passage-ways having a sectional area not greater than 6 feet by 6 feet;

(*d*) No district shall have its length, when parallel to the general trend of the adjoining shore, greater than 1 mile;

(*e*) A proposed system of working the mineral in each submarine area shall, before work is commenced, be submitted to and approved of by the inspector; and no change shall be made in such approved system without the written sanction of the inspector;

(*f*) The opening of a new level or lift in a mine already working in a submarine area shall be deemed the commencement of a new winning within the meaning of this section.

(2) The owner, agent or manager of any mine to which this section applies, who contravenes or fails to comply with any provision of this section, shall each be liable to a penalty not exceeding 1,000 dollars [£200], and if the offence complained of is continued or repeated after a written notice has been given by the inspector to such owner, agent or manager of any such offence having been committed, the Supreme Court or a judge thereof, whether any other proceedings have or have not been taken, may, upon application by the Attorney-general, prohibit by injunction the working of such mine; provided that the Commissioner may waive or modify any of the provisions of this section, when, on the report of the inspector, it appears to his satisfaction that valuable coal-areas cannot be otherwise wrought or mined. Revised Statutes, c. 8, s. 55; 1896, c. 12, s. 1.

Mr. T. E. Forster, replying to the discussion, said that he would answer the questions raised as to the Boulder-clay. Of course, the difficulty pointed out in the paper was that in this part of the country (it was perhaps different in the Firth of Forth) the clay was so erratic in its thickness. Even if they were to bore a hole from the workings upward to prove the thickness of the clay, they had no guarantee that 300 feet away there was any clay at all. To make the clay-capping of any use in settling the distance, they would have to explore the whole field with bore-holes every here and there, and it was hardly practicable to do that from underground; that was one of the disadvantages of working under the sea, though perhaps the absence of land-drainage might

counter-balance the disadvantages. That, however, was the reason why the distance had been fixed at what might seem a large one to those who were working under the Firth of Forth.

As to the method of working, the paper was meant to be a record of what had been done rather than as a guide to what might be done, and it was not intended to lay down regulations or suggestions as to how to work sea-coal. It had always been the idea here that every place ought to stand by itself under its own conditions. The depth of the sea, the thickness of cover and of alluvium were points to be taken into consideration. The great point was to consider what had already been found practicable in the neighbourhood. In an old coal-field, they could always find instances of one seam being worked under the waste of another, and putting one thing with another they could form a conclusion as to the thickness of strata necessary. They must put a margin of safety: 120 feet in some instances was considered sufficient, while in others this would bring down water. There were no heavy feeders: a certain quantity of water came down in the case of coal worked by bord-and-pillar after the pillars were removed, but this generally ceased after a time, and permanent feeders were very slight. The water was not very salt—only brackish.

As to the methods of working by bord-and-pillar and long-wall, at Cambois colliery, up to 360 feet of cover the whole of the seam, 4 to 4½ feet thick, was worked out by bord-and-pillar. The pillars were taken out, and no packing was put in. The strata did not fall very far up in that district—about 12 or 15 feet—and then it became jammed. Farther south, where the coal was being removed at a depth of 300 feet, the whole of the workings were being packed. Regarding the strata overlying the seams, it was pointed out that some information as to the thickness of the different beds might be of interest. As a rule, there were no abnormal thick beds of any one material; there were beds of post, sometimes 60 to 70 feet thick, but they varied very greatly. At Cambois colliery, sandstones formed 57 per cent. of the strata, while within 1 or 2 miles they were only 42 per cent. These were shaft-sections, and the sandstones might be thicker near the shaft in one section than in another.

As to the possible extension of the coal-field farther eastward, and the reason that an anticline might be met with and the seams dip to the sea: farther south, the beds about New-

castle all dipped in that direction, and at Wallsend they began to rise towards the mouth of the river, and that easterly rise continued for a certain distance along the coast. In Durham, the direction was changed.

Some discussion took place at the last meeting as to working sea-coal, and he made some remarks about the Workington disaster. The account of this disaster seemed to have pursued the subject of undersea coal-mining all over the world, and most engineers were under the impression that it was due to an inburst of the sea. A reference to the report of the discussion in the *Transactions** would show that the workings were holed into an old river-bed. The course of the river-bed was known, and they worked into it, although they had had warnings for some days before that there was danger in front of them; but, like many other people, they wanted the coal, and neglected the necessary precautions.

The CHAIRMAN (Mr. J. S. Dixon) moved a vote of thanks to Mr. Forster for his valuable paper.

Mr. C. C. LEACH seconded the resolution, which was cordially approved.

Mr. M. R. KIRBY's paper on "Steam-generation by the Gases from Beehive Coke-ovens" was read as follows:

* *Trans. Inst. M.E.*, 1902, vol. xxiii., page 663.

STEAM-GENERATION BY THE GASES FROM BEEHIVE COKE-OVENS.

By M. R. KIRBY.

Beehive coke-ovens have been used since 1765, when several were working on the Tyne. They have been described by Mr. A. L. Steavenson in his paper on "The Manufacture of Coke in the Newcastle and Durham Districts," read in 1860.* This class of oven was in general use in 1855, when flues and chimneys were added by Mr. A. L. Steavenson, who further improved them in 1860, by placing boilers on the flues and utilizing the heat of the waste-gases for raising steam.

The writer proposes to give a few particulars of the steam-generating plant at the collieries with which he is connected.

One ton of coal, in coking, gives off 6·85 tons of burnt gas, and uses about 6·45 tons of air, a weight about 25 per cent. more than that required for complete combustion. The heat given off during the process is 16,299,000 British thermal units; and, if properly used, it would generate 7½ tons of steam from and at 212° Fahr., but in practice the evaporation is about 1·3 tons. The specific gravity of the burnt gas is about 1·1 and its specific heat is 0·251.

The approximate composition of the coal, coke and gases is given in Table I.

TABLE I.

	Coal.	Coke.	Unburnt Gas.	Burnt Gas.
Carbon (C)	83·0	92·7	68·50	—
Carbon dioxide (CO_2)	—	—		14·68
Water (H_2O)	7·3	—	18·25	5·92
Hydrogen (H)	3·7	—	9·25	—
Oxygen (O)	—	—		0·38
Nitrogen (N_2)	1·0	—	2·50	75·42
Sulphur (S)	0·6	—	1·50	—
Sulphurous Acid (SO_2)	—	—	—	0·17
Ash	4·4	7·3	—	—

* *Trans. N.E. Inst.*, vol. viii., page 109; and vol. ix., page 35.

At Browney, South Brancepeth and Tursdale collieries, the beehive coke-ovens are 11½ feet in diameter by 7 feet high inside. The coal coked per oven per fortnight is about 22 tons, making the rate of coking 146·6 pounds of coal per oven per hour. The gas given off is about 1,004 pounds per hour, and the heat is about 1,066,660 British thermal units per hour per oven.

TABLE II.—BOILER-PERFORMANCES AT BROWNEY, SOUTH BRANCEPETH AND TURSDALE COLLIERIES.

	Browney.	Tursdale.	South Brancepeth.
Number of boilers	6	8	10
Heating surface, square feet	8,130	8,530	7,391
Number of beehive coke-ovens	262	223	246
Heating surface per oven, square feet ...	31	38	30
Working pressure of boilers, per square inch, pounds	50	40	40
Temperature of feed-water, Fahr. degrees ..	120	180	177
Evaporation of water per hour, pounds ...	45,860	38,000	31,000
Evaporation of water per oven per hour, pounds	175	170	126
Evaporation of water per square foot of heating surface per hour, pounds ..	5·64	4·45	4·19
British thermal units used per oven per hour	189,900	172,550	128,268
Efficiency, per cent.	17·8	16·1	12

Table II. gives particulars of the boiler-performances at these collieries. It will be seen that the plant at Browney colliery is much more efficient than at any of the others; and this is probably due to the fact that the boilers are of more modern design, comprizing 2 Galloway, 3 five-flued and 1 Lancashire boiler. Tursdale colliery comes next, with 6 Lancashire and Galloway, and 2 egg-ended boilers. While at South Brancepeth colliery, where the efficiency is lowest, there are 2 Lancashire, 1 Galloway, 2 French, and 5 egg-ended boilers.

A more complete series of tests was made on No. 2 boiler at South Brancepeth colliery in July and August, 1902, and the results are recorded in Table III. The temperatures in the flues were measured with a Siemens pyrometer, and the water with a Guest-and-Chrimes water-meter, which was repaired and tested previous to the experiments. The boiler was scaled before the tests were begun.

TABLE III. -TEST OF NO. 2 BOILER AT SOUTH BRANCEPETH COLLIERIES, 1902.

Type of boiler, Lancashire, 30 feet long and 8 feet in diameter, fitted with cross-tubes in the flues.

Heating surface, square feet	1,100
Number of coke-ovens firing this boiler	25
Steam-pressure, pounds per square inch	40
Temperature of feed-water, Fahr. degrees	177
Dimensions of chimney *: height, feet	75
,, ,, side of inside square, feet...	9
Heating surface of boiler per oven, square feet	44

* This chimney will not draw from more than 25 coke-ovens.

1902. July and August.	Temperature.		Draught of Boiler Measured in Water-column.		Water evaporated per Hour.
	At Front of Boiler.	In Flues at Back.	Front.	Back.	
	Degs. Fahr.	Degs. Fahr.	Inch.	Inch.	Pounds.
Monday	1,412	322	—	—	2,700
Tuesday	1,801	488	0·15	0·40	3,330
Wednesday	2,048	465	0·15	0·40	4,630
Thursday	2,212	440	0·15	0·45	4,990
Friday	2,390	467	0·15	0·55	4,990
Monday	2,092	552	0·15	0·50	3,760
Tuesday	2,087	352	0·15	0·45	4,750
Wednesday	1,962	484	0·15	0·50	4,990
Thursday	2,474	484	0·15	0·55	4,770
Friday	2,346	482	0·15	0·55	—

The average evaporation of water per oven per hour was 165 pounds, and 3·9 pounds per square foot of heating surface of boiler per hour. The efficiency of the boiler is about 16 per cent. Neglecting the loss due to radiation from the boiler, which is comparatively small, the other losses are shown in Table IV.

TABLE IV.—DISTRIBUTION OF HEAT PRODUCED FROM COKE-OVENS.

	Heat per Hour from 1 Oven.	
	British Thermal Units.	Per Cent.
Loss: By radiation from coke-ovens, flues, etc. ...	794,244	74·4
By heat in gases at chimney	100,800	9·5
Total loss	895,044	83·9
Utilized: Heat used in raising steam	171,616	16·1
Total heat accounted for	1,066,660	100·0

It would seem to be possible to reduce largely the loss due to radiation from the coke-ovens and flues, by covering them thickly with sand or masonry. But, assuming this loss to be inevitable, the writer considers that in Lancashire and similar boilers about 30 square feet of heating surface should be allowed per oven, in order to secure the full value of the boiler; and, consequently, 37 ovens should be applied to a boiler similar to that tested at South Brancepeth colliery.

In the writer's experience, in order to draw the gases from this number of ovens through a Lancashire boiler, a chimney 100 feet high and having an area of 1 foot to 1·25 square feet per oven is necessary.

Figs. 1, 2, 3 and 4 (Plate XI.) give the details of the seating of a Lancashire boiler which is being put down at Tursdale colliery, with 1,040 square feet of heating surface. It is intended to fire this boiler with the gases from 40 beehive coke-ovens. A bye-pass flue is provided for use when the boiler is laid off, and provision is also made for hand-firing. The chimney is shown in Figs. 5, 6 and 7, and the dampers in Figs. 8 and 9 (Plate XI.).

The CHAIRMAN (Mr. J. S. Dixon) moved a vote of thanks to Mr. Kirby for his interesting paper.

Mr. M. WALTON BROWN seconded the resolution, which was cordially approved.

Mr. C. C. LEACH read the following paper on a "Corliss engined Fan at Seghill Colliery":—

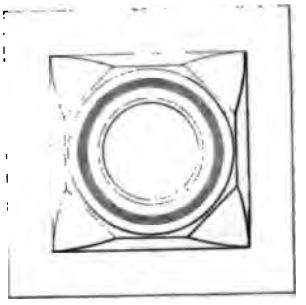


FIG. 7.—PLAN.

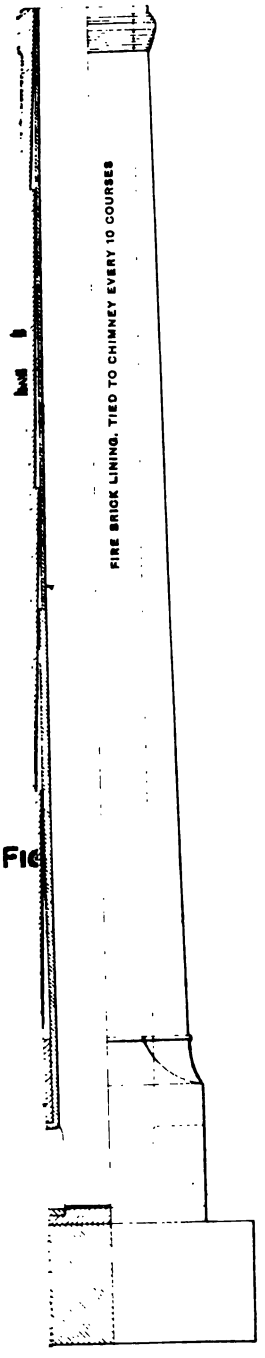


FIG. 5.—SECTION AND SIDE ELEVATION.

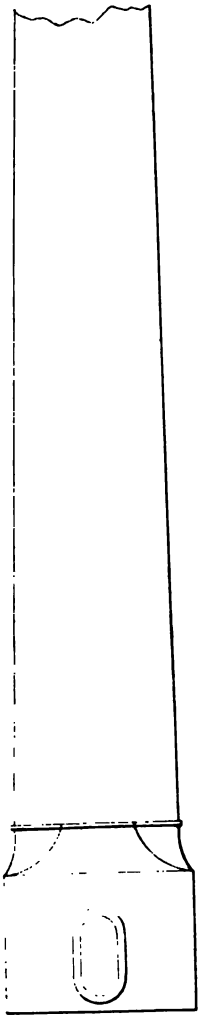


FIG. 6.
FRONT ELEVATION.

CORLISS-ENGINED FAN AT SEGHILL COLLIERY.*

By C. C. LEACH.

The Corliss-engined fan at Seghill colliery has now been running for 10 years, and the following particulars may be of interest.

Engine.—The valve-gear of the engine has required neither repairs nor adjustment: two of the trip-gear steel-plates have been turned round, as the edges were slightly worn and occasionally failed to open the valves; but this did not affect the speed of the engine. Two sets of piston-rings have been put in, one of them only a few weeks ago, and one set of plates for the metallic packing of the piston-rod has been replaced. The cylinder is hardly worn.

The engine has worked absolutely satisfactorily, and apparently will continue to do so for many years without overhauling; and the continuous work through day and night is equal to 30 years work at the rate of one shift a day.

Ventilation.—The following measurements of the air have been made so as to compare what the fan is now doing, with what it was doing when tested in 1893, and also to shew the improvement in the airways in the pit.

Tests have also been made to shew the effect of cleading the fan-drift, so as to turn the air into the inlet-opening of the fan and to lessen the air-eddies; and also of cleading the fan-race, at the end where the fan runs downward into it.

If the airways had remained in the same condition as they were in 1893, it would have required 2·42 inches of water-gauge to produce 131,004 cubic feet of air per minute instead of 0·96 inch, and 5·81 inches of water-gauge for 208,170 cubic feet of air per minute instead of 2·17 inches of water-gauge.

* *Trans. Inst. M.E.*, 1893, vol. vi., page 48.

TABLE I.—FAN-EXPERIMENTS MADE ON JULY 19TH, 1902.

Approximate Speed of Fan in Revolutions per Minute.	40		
Conditions of Experiment.	A	B	C
Condition of the mine	Ordinary	Ordinary	Ordir
Revolutions of fan per minute	40·25	38·01	40·
Revolution of anemometer, per minute	779	706	743
Velocity of air per minute, feet	771	705	736
Volume of air per minute, cubic feet	140,376	128,310	133,
Water-gauge in drift, inches	1·02	1·00	1·
Barometer in engine-house, inches	29·80	29·79	29·
Temperatures: air, wet bulb, degrees	50·5	51·5	54·
,, ,, dry bulb, degrees	54·2	59·5	62·
,, drift, wet bulb, degrees ...	58·0	58·0	58·
,, ,, dry bulb, degrees ...	58·0	58·0	58·
Boiler-pressure per square inch, pounds	100	100	100
Mean pressure of indicator-diagrams per square inch, pounds	29·95	27·08	29·
Indicated power of engine, horsepower ...	43·29	36·96	42·
Power utilized in air, horsepower	22·56	20·22	21·
Plant-efficiency, per cent.	52·11	54·71	49·

Approximate Speed of Fan in Revolutions per Minute.	60		
Conditions of Experiment.	A	B	C
Condition of the mine	Ordinary	Ordinary	Ordir
Revolutions of fan per minute	59·93	59·96	59·
Revolution of anemometer, per minute	1,157	1,111	1,1·
Velocity of air per minute, feet	1,134	1,088	1,1
Volume of air per minute, cubic feet	206,388	198,071	205,(
Water-gauge in drift, inches	2·25	2·15	2·
Barometer in engine-house, inches	29·79	29·79	29·
Temperatures: air, wet bulb, degrees	51·2	52·5	54·
,, ,, dry bulb, degrees	55·5	59·0	62·
,, drift, wet bulb, degrees... ..	57·5	57·5	57·
,, ,, dry bulb, degrees	58·0	58·0	58·
Boiler-pressure per square inch, pounds ...	100	100	100
Mean pressure of indicator-diagrams per square inch, pounds	64·02	60·15	62·
Indicated power of engine, horsepower	137·77	129·51	133·
Power utilized in air, horsepower .	73·17	67·10	69·
Plant-efficiency, per cent.	53·11	51·81	52·

Reference: A, cleadings in fan-drift and on fan race; B, cleading only in fan-drift; C, wi any cleading, as in 1893.

The increase in the volume of air and the decrease in water-gauge is due to improvements in the shafts and airw namely:- The John (downcast) shaft has been widened fro diameter of 8½ feet to 12 feet, for a length of 300 feet to Yard seam, the wooden guides have been replaced by steel- guides, longer cages are used, and a steam-pipe, 10 inches diameter, has been taken out of this shaft for a length of 456 f

In the Engine (downcast) shaft, 11½ feet in diameter, the brattice-division has been removed from top to bottom for a length of 456 feet, and 4 cages and wooden guides have been replaced by 2 big cages and steel-rail guides.

TABLE II.—THE FAN-EXPERIMENTS OF 1893 ARE COMPARED WITH THOSE OF 1902, BOTH SERIES BEING REDUCED TO SPEEDS OF 40 AND 60 REVOLUTIONS PER MINUTE.

Revolutions of Fan per Minute.	40			
Conditions of Experiment.	A	B	C	C_1
Date of Experiment.	1902.	1902.	1902.	1893.
Volume of air per minute, cubic feet ...	139,777	135,027	131,004	88,400
Water-gauge in fan-drift, inches	1·01	1·11	0·96	1·10
Indicated power of engine, horsepower* ...	43·29	36·96	42·93	29·61
Equivalent orifice of mine, square feet ..	52·44	48·94	50·04	31·44

Revolutions of Fan per Minute.	60			
Conditions of Experiment.	A	B	C	C_1
Date of Experiment.	1902.	1902.	1902.	1893.
Volume of air per minute, cubic feet ...	206,630	198,207	208,170	134,000
Water-gauge in fan-drift, inches	2·26	2·16	2·17	2·42
Indicated power of engine, horsepower* ...	137·77	129·51	133·94	96·11
Equivalent orifice of mine, square feet ...	51·65	50·51	52·52	32·26

* Not corrected.

The return and intake airways have also been improved, and in some cases doubled, and larger openings have been made into the upcast shaft, which is 11 feet in diameter.

In 1893, there were 10 main splits of air, with a total length of 96,000 feet, and in 1902, there were 12 main splits with a length of 163,000 feet.

Mr. T. H. BAILEY (Birmingham) said that the members were indebted to Mr. Leach for going so minutely into the particulars which were contained in the tables accompanying his paper, as they enabled others to see some of the mistakes and difficulties under which Mr. Leach had been labouring. He asked what was the area of the shaft, of the fan-drift, and of the opening from the shaft into the fan-drift.

Mr. C. L. WATSON (New Tredegar) said that at the Powell Duffryn collieries, South Wales, several fans, dealing with very large quantities of air and mostly of the Walker-Guibal type, were in use, driven by Corliss-valved engines. The engines in each case were compound condensing, and very good results had been obtained from the Corliss valves. All the newer engines, including the winding-engines at their new colliery at Bargoed, which were compound with four cylinders, were being fitted with Corliss valves and expansion-gear.

Mr. J. A. G. Ross (Newcastle-upon-Tyne) said that one advantage of the Corliss valve was that it was so very susceptible: it was so delicate that the governor acting upon it cut off steam in proportion to the work done, and if at any instant there was a sudden demand for work they could instantly raise full steam. A Corliss engine was erected at the Elswick engine-works, about 30 years ago, and it had always worked satisfactorily. The Corliss valve worked economically and with little friction; and the trip-gear was delicate, and worked with the slightest movement.

The CHAIRMAN (Mr. J. S. Dixon) remarked that he had no doubt that the enlargement in the airways had been of considerable advantage. The old theory of ventilation was summed up in the words "big airways."

Mr. C. C. LEACH said that the paper was really a continuation of one read when the fan was started some years ago.* The fan-drift had an area of 191 square feet, and the openings into the shaft were as large as they could be made.

Mr. C. H. INNES (Newcastle-upon-Tyne) wrote that he had read with much interest Mr. Leach's paper on the Seghill fan: the tests had evidently been made with care, and were of scientific as well as practical value. The accuracy of the tests was shewn by the fact that in each pair of tests, A, B and C, the equivalent orifice was practically constant, and the discharge in cubic feet per minute was very nearly proportional to the revolutions: for example, in the two tests A, it was 3,509 by revolutions, and 3,439 by revolutions. The water-gauge was also very nearly proportional to the square of the revolutions, thus in test A it was

* *Trans. Inst. M.E.*, 1893, vol. vi., page 48.

revolutions squared divided by 1,568 and revolutions squared divided by 1,600. Under these circumstances, he (Mr. Innes) thought it a great pity that details were omitted that should, where possible, be given for every fan-test. In the first place, the leading dimensions of the fan should be given, the diameter of the wheel, the diameter and number of inlets, the breadths at the internal and the external radii, and the angles made by the vanes with the tangents at the inner and outer circumferences; the dimensions of the diffuser, if any, and the sections of the volute by 4 planes at right angles, the first being taken by a plane passing through the axis of 90 degrees from the beak of the volute; and a drawing of the fan should also have been given. The position of the water-gauge should also be stated, and whether its end was turned like that of a Pitot tube, in a direction opposite to that of the air-current, or whether it was placed at right angles to it. Messrs. Heenan & Gilbert's tests with a fan, published some years ago,* showed the importance of the tip given to the water-gauge. The manner of measuring the discharge should be fully explained and illustrated by a drawing, showing how the fan-drift or the top of the chimney was divided into suitable areas. It should also be stated whether the fan was driven direct or otherwise. Had Mr. Leach supplied this information it would have increased the value of the tests. It was strange that the mechanical efficiencies at 60 revolutions were on the average so very little better than those at 40. The efficiency of an engine increased with the mean pressure, while that of the fan remained constant for a given equivalent orifice, so that the combined efficiency should increase.

The CHAIRMAN (Mr. J. S. Dixon) moved a vote of thanks to Mr. Leach for his valuable paper.

Mr. BAILEY seconded the resolution, which was cordially approved.

Mr. W. BLAKEMORE's paper on "The Fernie Explosion," was read as follows:—

* *Minutes of Proceedings of the Institution of Civil Engineers*, 1896, vol. cxxiii., pages 272-294.

THE FERNIE EXPLOSION.

By W. BLAKEMORE, Montreal.

On May 22nd, 1902, at 7 p.m., an explosion occurred in the Fernie mines of the Crow's Nest Pass Coal Company, resulting in the death of 130 men. The first evidence of the explosion was conveyed to the outside world by a roaring noise, and a cloud of dust blown from the mouth of No. 2 mine, and through the roof of the fan-house, situated near by, to an alleged height of 1,000 feet in the air. There was just one blast and then all was still — no flame and no smoke. The roof was blown off the fan-house and the large trap-doors overlying the air-channel were also blown away; this saved the fan, which was not injured in the slightest degree, but continued to revolve as if nothing had happened. In the course of 2 hours, the roof of the fan-house was sufficiently repaired to allow of the fan doing effective work — and a party of rescuers at once made their way into the mine.

At this point it may be interesting to mention that the mine in question is situate upon the southern bank of Coal creek, a mountain-stream which flows into the Elk river, the mine being situate about 5 miles from the river and from the town of Fernie, from which it takes its name. The coal-field is the now well known Crows Nest Pass district, a basin some 40 miles in length by 10 miles in width, containing upwards of twenty seams of high-grade bituminous coking coal. The No. 2 mine, with an output of about 1,500 tons a day, had been in operation for four years, and had worked out an approximate area of 100 acres. The system adopted was bord-and-pillar, the rooms being 20 feet wide and the pillars 30 feet thick, with cross-cuts 20 feet wide driven every 100 feet. The seam worked was 6 feet thick, with a strong sandstone-roof and a hard shale-floor; the coal itself being soft and friable, and yielding not more than 50 per cent.

of coal passing over 1 inch mesh. The mine, being practically free from water, was dry and dusty, and a considerable amount of gas was produced and could generally be detected. The seam dipped at an angle varying from 5 to 20 degrees from the main level, nearly all the workings being to the deep. This description will give some idea of the character of the mine, and will make it easy to follow the description of the explosion.

The first thing which the rescuing party discovered was that the main air-crossings had been blown out. Of these there were two, one at A, and the other at B (Fig. 1, Plate XII.), the one at A being about 1,200 feet from the entrance of the mine and that at B some 300 feet further inbye. It was discovered, in addition to this, that nearly all the air-stoppings alongside the main deep and the main level had been blown out, from which it will at once be observed that the ventilation had been destroyed by the explosion, and that the circulation when the mine was re-entered could only extend from the entrance of No. 2 mine as far as A or B and back to the fan-house.

The work of the rescue-party extended over four weeks: and, at the end of that time, every part of the mine had been visited, and all the bodies recovered except four, which are still in the mine and probably lie buried under débris. With the exceptions noted hereafter, all the bodies were found in the places where the men were known to be at work, death in every instance having been instantaneous. The exception is in the case of workmen, from what is known as the high line or No. 1 district (Fig. 1, Plate XII.), who were rallied by their boss, a young Englishman named Brearley, and led out of the working-places until they came to E, on their way to the exit, when they ran into the after-damp which was rapidly travelling upward from the lower workings, and were overpowered. When found, they were lying together with Brearley at their head, with their lamps in their hands, in the position of men who had just fallen down through suffocation. The number of this party was 22. The other exception, referred to, was in the case of the men from No. 3 mine which is connected with No. 2 mine. These men were working in the eastern section of No. 3 mine, to the number of 24. What happened to them may be best described in the words of one of the survivors, who gave evidence at the inquest, Charles Burrows. He said:—

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We were at work, when all at once I felt a peculiar ringing in my ears, and then a pressure as if my head would be burst in. I heard no noise, but the lights went out [all the men in No. 3 mine were working with naked lights]; I knew what it meant, because I had been in an explosion in Nova Scotia, so I shouted and said "Boys, there's been an explosion let us get out." We all got together and started for the deep and commenced to travel up; at the corner [F] we met the after-damp, but it was not very strong and we continued our way, running, walking, and sometimes crawling, until we got within 50 or 60 feet of the entrance to the mine. The after-damp had been getting stronger, and here it overpowered us; some of the men fell to the ground, I fell and in stretching out my hand to save myself I put it into the dust which lay along the side of the road, and it felt so hot that I thought my hand was burnt, and quickly pulled it away again; I staggered on, and finally fell down within a few feet of the entrance to the mine, and I knew no more until I found myself outside.

The whole of these men were rescued by a party from the outside, having made their way so near to the entrance of the mine that they could be seen. The evidence of Charles Burrows, which was confirmed by others of his fellows, is extremely interesting as illustrating the effect of the explosion upon the men themselves, and upon the coal-dust, which at a distance of at least 3,000 feet from the supposed origin of the explosion, and in a part of the mine where there was considerable water and no gas, was found to be heated to the point of almost burning the men. This fact is well worth study.

All the other men, who were killed, were found at or near to their working-places, and most of them had not moved. The working-places, generally speaking, are shown in Fig. 1 (Plate XII.) comprizing No. 3 mine, west side; and No. 2 mine, No. 2 district, No. 3 district, MacDonald level and Beaver level, upwards of 100 men being recovered from these places, the total number of men in the mine being 154.

The evidence showed that, with few exceptions, the men were killed by after-damp, the exceptions being somewhat peculiar, and clearly illustrating the fact that there must have been local explosions, very limited in extent, but terrific in force, and that these must have occurred immediately after the main explosion. This is shown by the fact that at G, in No. 1 room of the MacDonald level, at H, near the face of the MacDonald level, and at I, in No. 1 machine-room, the bodies of men were found terribly mutilated, whilst in the intervening working-places the bodies were unmarked and indicated that the victims had died a painless death.

This leads to the consideration of the probable locality and cause of the explosion, and upon this point it is only fair to state that two totally distinct theories were put forward at the inquest, both strongly supported by evidence, and that after a most carefully conducted inquiry extending over a fortnight the jury were unable to decide in favour of either theory, and so left that part of the matter an open question. The theory brought forward by the workmen's committee, which examined the mine after the explosion, attributed its origin to the firing of a shot in a cross-cut near the face of No. 1 machine-room at C (Fig. 1, Plate XII.). The evidence upon which the workmen's committee based their theory was as follows:—The appearance of the cross-cut indicated that a shot had been fired during the shift, which had just started when the explosion took place. They found coal down, which they could not account for on any other supposition. The body of the shot-firer was blown against the face of the room, and the position of the hose-pipes and one empty car was consistent with an explosion having taken place at the point indicated. Further, the men, who were most experienced and competent miners, swore positively that, when travelling from C across the main deep and along the main return-airway in the direction of the MacDonald level (the airway being marked J on Fig. 1), they found the timbers and brattice blown in the direction of the MacDonald level.

Having heard this evidence, as well as that given in contradiction, the writer is driven to the following conclusion, and it is one which it will be well to discuss, namely:—Either that the original explosion occurred at C, or that there was a local explosion: one or the other being necessary to account for the position of some of the bodies and appliances in the No. 1 machine-room. If, after considering all that remains to be said on this subject, it is thought that a local explosion could be produced at this point, subsidiary to the greater explosion, then the writer thinks that it would be sufficient to account for the conditions presented.

The other theory, put forward by the management and supported by the Government experts, is that at the face of the MacDonald level, at D, where a small feeder of gas was known to exist, and was found still to be giving off gas after the explosion,

the gas was fired and conveyed the explosion to the coal-dust, which was abundant in that part of the mine, and thence it was spread throughout the workings. In support of this latter theory, it must be admitted that there is a strong point in the actual presence of a feeder of gas at the place indicated, but the question of how it was fired will forever remain a mystery. The experts claimed that they were able to trace the direction of the force of the explosion from D outward along the MacDonald level and the working-rooms therein to G: part of the force travelling through the airway, J, to the west, and part through the airway, K, leading to the No. 3 mine. In this connection it must be noted that the chief-superintendent of the company attributed the widespread character of the explosion to the dust, which had accumulated in the old workings, the area of which is stated to be upwards of 100 acres. Matches were found in the pockets of some of the miners, as well as pipes and tobacco, but none were found in the pockets of the men recovered from the MacDonald level.

We have now sufficient information to enable us to weigh to some extent the probabilities connected with this terrible disaster, and to suggest some important considerations. As to the possible cause of the explosion, it should be borne in mind that, although the mine was known to be gaseous, and naked lights had been abolished for some 2 years or more, as a matter of fact the mine had been reported free from gas for many months, and the Government inspector of mines, who made a monthly examination, had failed to discover gas during the present year. Therefore it may be taken for granted that the mine was considered (on all hands) to be free from gas at the date of the explosion. There is the further consideration that no prospective headings were in operation, which could unexpectedly tap a large feeder, and that, so far as is known, and indeed as the writer thinks results prove, there was no accumulation of gas in the old workings. On the other hand, the evidence showed (and on this point there was abundant evidence) that throughout the whole of the mine there was a considerable accumulation of coal-dust. In the main roads, and especially in the main deep (Fig. 1, Plate XII.), it was said to have accumulated to a depth of 18 or 20 inches. In the old workings, it was admitted by all parties that no dust

whatever had been removed since the workings were shut off, and that there was a considerable quantity there. The only attempt to remove dust was at the working-faces, where it was taken out before shots were fired. It is admitted that the system of removing the dust was very imperfect, there being no regular staff of men employed for the purpose, and no rule for constant removal. The evidence seemed to show that it was removed chiefly when it became an impediment to haulage. With the exception of three or four points in the mine, where there were sudden alterations of gradient and the water which was naturally given off by the strata accumulated, the whole of the mine was dry, and in pursuance of the requirements of the Coal-mines Regulation Act it was customary to do some watering in the working-places before firing a shot. This, however, was not systematized, the only appliance being an ordinary wooden tub with a bucket or can, and the evidence distinctly showed that with such appliances the amount of water was quite inadequate. It will be seen from the foregoing facts that, whatever may have been the case with respect to gas, there was a sufficient accumulation of dry coal-dust, throughout the mine, to produce a terrific explosion if it were once started, and the only problem in the whole case is as to how it was started.

The writer is disposed to think that a careful study of the conditions existing, in the light of experiments recently made with coal-dust, might possibly lead to the conclusion that this explosion, like many others, might have originated without the assistance of gas. Experienced miners employed in this mine deposed to the fact that the atmosphere was so loaded with dust that it would accumulate upon the lamp, and that upon shaking the latter to get rid of the dust they have frequently known the lamp to be filled with flame, in a number of places where there was no possibility of gas being present. The question is whether, in such a mixture of coal-dust and air, such a flame might not communicate with the air surrounding the lamp and so precipitate an explosion. Then there is the further condition known to exist of constant blasting, in a mine in which the atmosphere was charged with dry coal-dust. Is it within the knowledge of any of the members that under such conditions an explosion has been produced without the presence of gas? There is abundant evidence, repeated again and again, to show that in the Fernie

mine coal-dust has been frequently set on fire by a blast, and great difficulty has been experienced in extinguishing it. Is it possible that this ignition may have gone to the point of explosion? If either of these latter questions can be answered in the affirmative, it would not be necessary to look any further for the cause of the Fernie explosion; but as the other theory referred to was so firmly held by the Government experts it is only fair to examine it, and in this connection the first qualifying consideration is that the lamp in use must be undoubtedly classed among the defective safetys. It is a simple bonnetted Clanny lamp, and, within a few feet of D where the small feeder of gas existed, one of these lamps was found completely shattered and evidently blown to pieces by the force of the explosion, whether the original one or not it is impossible to say. But certainly an important factor in the case is the presence in the mine of a lamp of this class, which in contact with any feeder of gas would immediately become an instrument of danger and of possible ignition.

The theory that the small feeder of gas, referred to, originated the explosion is not, in the writer's opinion, a very strong one for the following reasons: (1) The quantity of gas given off was so small, that only in the case of almost incredible carelessness could it have accumulated in sufficient quantity to have caused an explosion. (2) It was known to exist a long time before the occurrence of the explosion, but it was so feeble that it could not be detected by a lamp, even when the lamp was held close to it, and one of the men, an experienced miner, who gave evidence, testified that the only way that he could devise was to place his ear close to the feeder when he could feel what he described as a small breath against his face. The Company's chief engineer, who supported this theory, admitted on cross-examination that he did not think the feeder yielded as much as 10 cubic feet per minute, and certainly the evidence tended to show that the quantity would be much less than this. Then there is the further difficulty that, according to the evidence of the chief engineer, there was an air-current of from 400 to 600 feet per minute velocity passing along the MacDonald level and at the very point where this gas-feeder existed, so that nothing could account for the ignition of the gas, so far as the writer is able to see, but an interference with the air-current which would allow the gas to accumulate instead of being carried off. How this could have continued long enough

with so feeble a feeder, to fill even the upper portion of the levels and bring the gas down to the lamps the writer is at a loss to understand, it being remembered that the gas-feeder was in the roof of the seam of coal, which was 6 feet high.

The only way in which the writer thinks that it is possible for this gas to have been ignited, without assuming the grossest possible negligence amounting to criminality, is best illustrated by Fig. 2 (Plate XII.), which shows the arrangements of brattic-ing at the point in question, the gas-feeder being shown at D. The MacDonald level, 12 feet wide and 6 feet high, was ventilated by means of board-brattice, extending from E to F, the air going in along the upper side and returning along the lower side to the Beaver level. At E, there was a door extending from E to G, through which the cars travelled upon the track to the face of the Beaver level; there was no check of any kind, so that when-ever the cars were run into the Beaver level, the door, E G, was open and possibly, as was admitted in the evidence, left open until the return of the driver. Such being the case, there would be an interval when ventilation would be entirely cut-off from the Mac-Donald level, and during that time the gas given off at the feeder, D, would be accumulating. The whole question is whether the accumulation would be sufficiently rapid to reach the danger-point before the ventilation was renewed by the closing of the door, E G; and in this connection one has to consider whether it is possible or probable that the men working at the face of the MacDonald level would be content to be deprived of air by allow-ing the door to remain open long enough for any considerable accumulation of gas to take place. Be that as it may, these are, so far as the writer has been able to discover, the only considera-tions bearing upon this suggestion as to the origin of the explosion.

In the course of the enquiry, many interesting views were brought forward, and as they led to much speculation and theor-izing, the writer will mention a few of them. There was a con-troversy between the Government experts and the miners, result-ing in a difference of opinion, as to the direction in which the force of the explosion travelled, and it is significant that two bodies of experienced men travelling over the same ground, noticeably between No. 1 machine-room and C, along the airway, J, and the MacDonald level should resolutely maintain that the

evidences of direction were exactly opposite, the workmen maintaining that the evidence all pointed to the forces having travelled from C towards the MacDonald level and the Government experts maintaining that it travelled in exactly the opposite direction. On this subject of conflicting direction of forces, the writer concluded long ago, and the Fernie explosion has confirmed it, that there is no persistent direction resulting from a great explosion of this kind, but that where (as in this case) the explosion covers the whole of the mine, the force manifests itself according to the weakest point of resistance in every possible direction. Thus, taking the main deep (Fig. 1, Plate XII.), nearly all the air-stoppings on the eastern side of the main deep were blown westward towards the deep, while several of the air-stoppings on the western side of the main deep were blown eastward. In many of the rooms, also, there were evidences of the tools having been blown in different directions in the same room, so that one is driven to the conclusion that wherever the explosion originated, and however it spread through the mine, whether as one continuous blast or in the form of one original blast and a number of local explosions, the evidence of direction of force is both conflicting and erratic.

Another interesting question raised and greatly debated was as to the position in which coal-dust would be found, upon the posts standing perpendicularly in a road or airway along which passed the blast from the explosion. Some of the witnesses maintained that the force of the explosion would drive the dust into the sides of the timber upon the side nearest to the direction from which the blast came, while others maintained that the force of the blast would clean that side of the post and leave the coal-dust adhering upon what may be called the far side. In the writer's experience both are correct, to a certain extent. Given the case of a post upon which there was already a certain accumulation of coal-dust, the writer is convinced that a strong blast would hurl the minute particles of dust on the near side of the post and drive them into it so that they would be discovered by explorers, and at the same time dust might remain upon the far side of the post if it had previously been there. It will be interesting to hear what any of the members, who have had experience in explosions, have to say upon this point, because undoubtedly there are cases in which conclusive evidence as to direction of force may be

extremely important in fixing the location whence the explosion started originally.

The writer finds, however, that by far the most interesting aspect of the question, from the standpoint of the mining-engineer, is that this was essentially a coal-dust explosion. In company with the chief Government engineer, he hurried to the mine within a few hours after the explosion had occurred, and remained there for more than six weeks, being present throughout the Government enquiry, and he had no difficulty in coming to the conclusion that, whatever may have originated the explosion, it was coal-dust which carried it throughout the mine. There was no evidence whatever of the slightest quantity of gas at any point in the mine except the small gas-feeder already referred to, and this was so inconsiderable in quantity that, but for the other prevailing conditions, the effects of the explosion would have been confined to the face of the MacDonald level and the loss of life would probably not have been more than 2 or 3 men. In his experience, extending over thirty years, there has been no explosion so directly attributable in all its disastrous results to the presence of coal-dust, nor one more calculated to arouse the mining-engineer to a sense of responsibility in dealing with what Prof. Galloway has properly called "a more dangerous element in coal-mines than gas." The behaviour of the coal-dust in this case is in itself an interesting matter for study, because it fully bears out the theory which has been laid down for several years as to what actually takes place under such conditions. There may have been a slight explosion of gas, the presence of coal-dust leading to the generation of carbonic oxide; this, distributed by the force of the explosion and coming into contact with floating bodies of dry coal-dust, caused instant distillation, the production of more carbonic oxide, the using up of whatever oxygen could be reached, and in several localities the production of further explosions. Upon this latter point, there can be no doubt, for the reasons stated earlier in this paper. So that it is possible with the mind's eye to see how in a few seconds this explosion, which was slight and local in its initiation, finding a suitable medium upon which to operate, ran throughout the whole of the mine with the speed of the electric fluid, producing universal ignition, concussion and local explosions, of which the

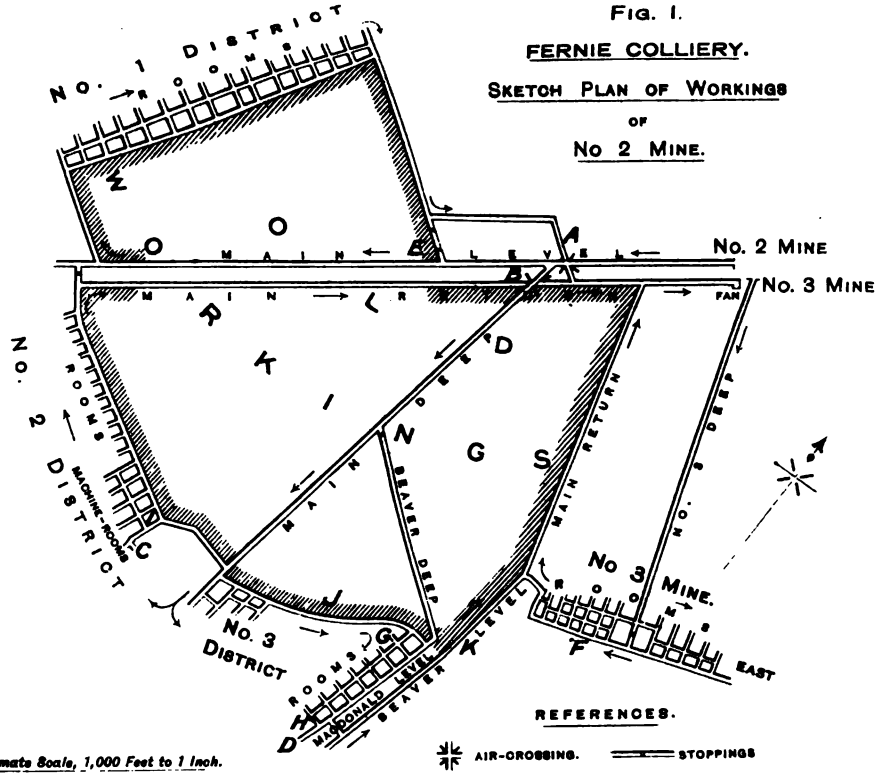
only constant feeder was an accumulation of coal-dust. This theory is fully borne out by the condition of the mine; for instance, in nearly all the working-places, where the coal-dust was freest and purest, there was considerable coking both upon the timbers and the sides of the working-places, whereas there was no coking discovered in the hauling-roads or airways. The writer attributes this to the greater facility with which the purer coal-dust yielded to the influence of the explosive current; it also explains the widespread production of after-damp.

There are some lessons which should be learned from this catastrophe, coming as it does upon the heels of others in which the same prominent features have predominated. The writer thinks that we may well begin to doubt the efficacy of "watering" as a preventive of coal-dust explosions. Not that it could be claimed that the watering adopted at the Fernie mine was in any sense thorough or satisfactory, but because there were considerable areas of the mine where water was lying or dripping, and yet these wet areas had no effect upon the spread of the explosion, which passed over or through them with apparently the same ease as would have been the case if they had been dry. Another deduction is that the evidence adduced at this inquiry with respect to the action of coal-dust upon a safety-lamp should lead to a study of the possible ignition of a mixture of coal-dust and air and the possible production of an explosion through this medium. The third conclusion, and one which has been forced home to the writer's mind more or less during the last ten years, is that blasting should be abolished in dry and dusty mines, apart altogether from the question of gas. In other Canadian mines, under the writer's control, he has known coal-dust to explode in a working-room as the result of a blast, and although there is no direct evidence of this in the Fernie mine, there is, as already stated, repeated evidence of coal-dust being fired. He would suggest further consideration as to the effects of violent concussion in agitating the particles of coal-dust which float in the air, and producing a degree of heat rendering the atmosphere highly inflammable and possibly susceptible to influences which would not be dangerous under other conditions. The writer has used most of the so-called safety-explosives, and has tested all those upon the Permitted List, and whilst he is, of course,

FIG. 1.

FERNIE COLLIERY.

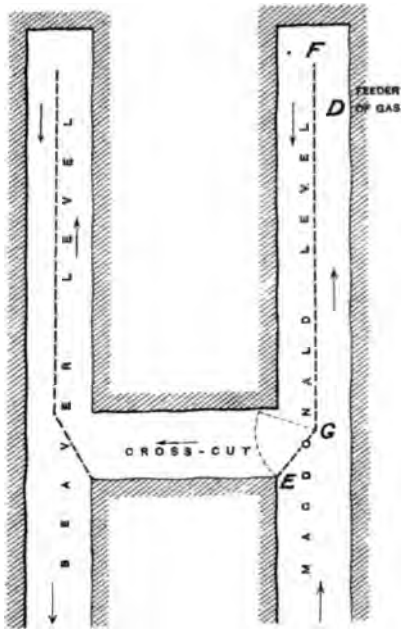
SKETCH PLAN OF WORKINGS OF No 2 MINE.



Approximate Scale, 1,000 Feet to 1 Inch.

FIG. 2.—FERNIE COLLIERY.

SKETCH PLAN ILLUSTRATING THE MODE OF VENTILATING THE MACDONALD AND BEAVER LEVELS.



Scale, 30 Feet to 1 Inch.

prepared to admit that a higher percentage of safety might be attained by some of these than with ordinary powder, he is convinced that none of them are absolutely as safe, as is popularly supposed: and he would go further and state that none of them are sufficiently safe to meet the reasonable requirements of modern mining. While with the better explosives there is a lessened danger of ignition of gas or coal-dust, there is no mitigation of the dangers arising from concussion (which have been referred to). The writer sincerely hopes that the day has nearly arrived when we shall have learned our lesson in this respect, and when the sacrifice of human life shall have been sufficient to purchase practical immunity from danger by the universal use of safety-lamps and the total abolition of blasting in all dry and dusty mines.

Mr. W. N. Atkinson (H.M. Inspector of Mines, Barlaston) wrote that Mr. Blakemore had no hesitation in attributing the extension of the Fernie explosion, and practically the whole of the damage done, to coal-dust; but he appeared to be in doubt as to whether such an explosion could be initiated without fire-damp, and asked, "Is it within the knowledge of any of the members that under such conditions an explosion has been produced without the presence of gas?"* It is well known that in this country a number of extensive explosions have been attributed by many engineers to the ignition of coal-dust in the complete absence of fire-damp, and the possibility of such explosions has been proved experimentally. It might have been supposed that the occurrence of extensive explosions in old collieries, like Camerton and Timsbury, in Somerset, where fire-damp had never been found, either before or after the explosions, would have set the question at rest; but possibly Mr. Blakemore had not seen accounts of those explosions.

It is not possible, from the brief account of the indications observed at Fernie colliery, to form any opinion as to the probable point of origin of the explosion, but a comparison of the conditions described at the two suggested points of origin leads him (Mr. Atkinson) to the conclusion that the point, C, where

* *Trans. Inst. M.E.*, 1902, vol. xxiv., page 455.

the shot was fired, was a more probable point of origin than the point, D, favoured by the experts, at the face of the MacDonald level.

The account of the attempted escape of Brearley and his companions from No. 1 district corresponds closely with what has been observed in other explosions, and illustrates the danger of rushing out from a district not affected by an explosion into roads traversed by it. If these men had remained in No. 1 district, and had done their best to prevent the after-damp from invading it, it is possible (if not probable) that they might have lived until the road out was sufficiently ventilated for them to be able to escape by it.

The escape of the men from the east side of No. 3 mine is, on the other hand, difficult to understand from the account and the plan. It would appear impossible for these men to travel up No. 3 deep directly after the explosion if that road had been traversed by the blast, as might be inferred by the fact that hot dust was found near the entrance. Possibly there are connections, not shown on the plan, between No. 3 deep and No. 2 mine, which might account for the presence of hot dust near the top of No. 3 deep, without that road having been traversed by the blast throughout. Or it may have been that hot or burning dust ejected from No. 2 mine had been drawn into No. 3 mine. Otherwise there must be some unrecorded circumstances to account for the escape of the men from the east side of No. 3 mine. The evidence in support of the statement "that there must have been local explosions, very limited in extent, but terrific in force, and that these must have occurred immediately after the first explosion,"* is not given in sufficient detail to carry conviction on the point. The fact that, at three places, the bodies of men were terribly mutilated, while men in intervening working-places had not been subject to force, might be capable of explanation in another way altogether, if the exact details of their positions at the time of the explosion and the configuration of the localities were fully known.

With reference to the theoretical statement concerning "the behaviour of the coal-dust," which it is said "fully bears out the theory which has been laid down for several years as to what actually takes places,"† it may be asked on what investigation of

* *Trans. Inst. M.E.*, 1902, vol. xxiv., page 452. † *Ibid.*, page 459.

the chemical re-actions occurring in a coal-dust explosion such theories are based.

Mr. DONALD M. D. STUART (Bristol) wrote that the subject of colliery-explosions had been carried to a more definite issue than appeared in this interesting paper upon the Fernie mine-explosion. The inception of the explosion was left in uncertainty between the opposing views of gas and coal-dust, and this could scarcely cause surprise when the conditions of the mine were taken into account. Mr. Blakemore stated that "the mine, being practically free from water, was dry and dusty, and a considerable amount of gas was produced and could generally be detected;"* and also "throughout the whole mine there was a considerable accumulation of coal-dust."†

In such circumstances, there was presumably reasonable ground for difference of opinion; but explosions had occurred in mines at home in which the two elements of gas and coal-dust did not co-exist, consequently there was no complication in determining which of the two agents was responsible for their inception. The explosions at the Camerton collieries in 1893, and at the Timsbury collieries in 1895, were evidence to the point. The two collieries were free from gas, in fact gas had never been found in the seams in which the explosions occurred, although they were worked in numerous other collieries in the district and were now approaching exhaustion. The seams had been worked with naked lights during their entire history, reaching back to the early years of the nineteenth century, and naked lights were used in them to this day. The only explosive agent in the mines was coal-dust, and the explosions were traced home to this agent. The potentiality of bituminous coal-dust to originate a mine-explosion was, therefore, a fact of experience, although the complexities in the Fernie mine disallowed such a definite conclusion. This fact in regard to coal-dust, however, did not warrant an alarmist feeling, nor did the experience in mines in Great Britain support the opinion that coal-dust was "a more dangerous element in coal-mines than gas."‡ The official records showed that explosions originated by ignition of coal-dust were an almost inappreciable fraction, compared with the explosions by ignition of gas.

* *Trans. Inst. M.E.*, 1902, vol. xxiv., page 451. † *Ibid.*, page 454.

‡ *Ibid.*, page 459.

The circumstances in the Fernie mine were suggestive as to the origin of the explosion. Gas was given off, safety-lamps were used, and matches, pipes and tobacco were found in the pockets of some of the men.* And with facts of this nature, it was not difficult to account for the original ignition. Mr. Blakemore seemed to support the supposition that a shot had been fired, and that the explosion was initiated by coal-dust, near a place where the bodies of some of the men were found terribly mutilated.† This mutilation Mr. Blakemore considered could only be accounted for by explosive violence. The observations made in explosions that had been traced home to shots igniting coal-dust, were that no violence was developed at the point of origin. The first exhibitions of violence in the Camerton and Timsbury collieries were distant 408 to 573 feet from the fatal shots. This condition was observed in the explosions that preceded as well as those that have occurred subsequently, and had been traced home to a similar cause. The origin of the explosion in the exhibition of violence at the place where the supposed shot was fired, was opposed by the observations at the point of origin of explosions at home. Mr. Blakemore evidently recognized the difficulty and offered an alternative explanation of the violent effects. He said "either that the original explosion occurred at C, or that there was a local explosion: one or the other being necessary to account for the position of some of the bodies and appliances."‡

The alternative of a local explosion led to what in his (Mr. Stuart's) opinion was the important point in the paper, the phenomena of propagation. Mr. Blakemore said that "the evidence showed that, with few exceptions, the men were killed by after-damp, the exceptions being somewhat peculiar, and clearly illustrating the fact that there must have been local explosions, very limited in extent, but terrific in force, and that these must have occurred immediately after the main explosion."§ The observation of facts contained the secret of propagation, and was capable of explaining all the phenomena of the explosion that the paper recorded. A distinctive phenomenon in the explosions at the Camerton and Timsbury collieries was, local explosions at intervals along the paths of coal-dust, limited in extent and

* *Trans. Inst. M.E.*, 1902, vol. xxiv., page 454.

† *Ibid.*, page 452. ‡ *Ibid.*, page 453. § *Ibid.*, page 452

terrible in force. These exhibitions of explosive violence were measured, with the distances between them, at the time; the facts were also recorded in the *Transactions*.* This theory of local explosions did not fit the idea of a continuous and instantaneous blast through the mine, which was in his (Mr. Stuart's) opinion the standing obstacle to the provision of effective means for the prevention of propagation of explosions and wreck of the workings. The idea utterly failed to explain the phenomena observed in the paths of the explosion, and it was matter for surprise and regret that the resultants of explosive forces which directly opposed the idea, were still pronounced "conflicting and erratic," while they were the handwriting of nature's laws revealing the causation of the explosion. He (Mr. Stuart) had noted other interesting phenomena in the paper, but considered that the theory of local explosions was the only key to their solution; and as propagated explosions were still occurring, causing calamitous loss of life and destruction of property, he (Mr. Stuart) thought that the Institution might, in accordance with its inception and history, undertake an investigation of this point, and, when another explosion occurred, depute two or three members to make exact records of the conditions left in the path of the explosion; and thus establish a foundation of fact for the understanding of propagated explosions, and consequently for their prevention.

Dr. J. S. HALDANE (Oxford) wrote that he had read Mr. Blakemore's paper with interest, but as to the debatable points raised in it, he should not care to add any criticisms without more precise information concerning the facts observed. He confessed that he did not understand either Mr. Blakemore's theory of the propagation of dust-explosions, or the exact grounds of his objection to safety-explosives and doubts as to the efficacy of watering and trustworthiness of safety-lamps in presence of dust.

Mr. J. B. ATKINSON (H.M. Inspector of Mines, Newcastle-upon-Tyne) wrote that Mr. Blakemore states that the main air-crossings and nearly all the air-stoppings alongside the main deep and the main level were blown out, but he does not state in which direction the force had passed: from the intake airway, and presumably haulage-road to the return airway or *vice versa*. There

* *Trans. Inst. M.E.*, 1896, vol. xii., page 371.

would probably be no difficulty in determining this, a most important indication.

With the exception of a party of 22 men, who had left their working-places and were found with their lamps in their hands suffocated by after-damp, all the other victims of the explosion were found dead in their working-places. Mr. Blakemore does not state, with reference to this party of 22 men, whether evidences of the explosion having reached their working-places were observed, or if they were burned; it is probable that both these questions could be answered in the negative, and if so the reason why the explosion had not reached them should have been discussed. Was there any absence of coal-dust to account for it, or was there any other reason?

The fact that the majority of the victims of the explosion, probably all who were in the actual field of flame, were found dead at their working-places is of great importance in determining the agent that led to the extension of the explosion. It appears, to him (Mr. Atkinson), impossible to suppose that the atmosphere of any considerable area of workings could become explosive owing to the presence of fire-damp, without the miners having observed gas firing in their lamps, and showing by their movements before the explosion evidences of alarm. If the inflammable agent is coal-dust, the reverse is true: the mine in its normal condition contains the elements of explosion: an air-wave, to raise the dust, and flame is all that is necessary to initiate a wide-spreading explosion. Where, as has several times happened, the miners are working with naked lights, at the first of which a sudden issue of fire-damp would ignite, the fact of there being no movement before the explosion is still stronger evidence that fire-damp could not be the inflammable agent. This matter was fully discussed in *Explosions in Coal-mines* by Mr. W. N. Atkinson and the writer, and was referred to by him in his evidence before the Coal-dust Commission.

With regard to the position in which coal-dust (whether coked or not) is found upon props standing perpendicularly in a road along which the explosion has passed, the experience of the writer in a large number of cases is that it is usually deposited or found in a direction opposite to that in which the explosion has travelled. In many of these instances, no doubt existed as to the direction in which the explosion had travelled, as when it had passed into

districts where no person was working at the moment of the explosion.

Sufficient data are not given to make it worth while discussing the point of origin of the explosion, but it may be stated that if coal-dust exists on the sides, roof and timbers, as well as on the floor, of an intake airway, there can be no reasonable doubt that a shot may in such a situation initiate a wide-spreading explosion in the entire absence of fire-damp. Such a result, however, is not so likely at the working-face, where the dust is coarse, and here the entire absence of fire-damp can rarely be asserted.

The feeder of gas referred to by Mr. Blakemore, amounting to 10 cubic feet per minute or 600 feet per hour, could easily accumulate, if not dissipated by ventilation, and form an explosive mixture quite sufficient to initiate an extensive explosion in a dusty mine.

The references to local explosions do not seem based on any satisfactory evidence; it seems more probable that there was only one explosion, varying no doubt at different points as regards the force developed.

It is stated that "in nearly all the working-places, where the coal-dust was freest and purest, there was considerable coking both upon the timbers and the sides of the working-places, whereas there was no coking discovered in the hauling-roads or airways. The writer (Mr. Blakemore) attributes this to the greater facility with which the purer coal-dust yielded to the influence of the explosive current."* There are probably errors in this statement, because:—(1) The freest and purest coal-dust exists on haulage-roads, particularly on their upper surfaces. (2) Greatest force is always developed on haulage-roads, where such fine dust exists. And (3) coal-dust exposed to rapid currents of air, on haulage-roads, seems to absorb oxygen from the air and loses its property of coking, and this may be the reason why coked dust is rarely observed in such situations.

The statement that wet areas had no effect upon the spread of the explosion should be supplemented, if possible, by details.

The remarks about shot-firing may be questioned. If all the dangers attending shot-firing in mines are thoroughly understood and guarded against, there seems to be no reason why shots should not be fired with safety.

* *Trans. Inst. M.E.*, 1902, vol. xxiv., page 460.

Mr. H. Hall (I.S.O., H.M. Inspector of Mines, Rainhill) wrote that Mr. Blakemore's account of the effects of the explosion at the Fernie colliery brought vividly back to his mind several of the great British explosions: the phenomena in each case being so similar that one description does for all. The members are not told, in so many words, what kind of explosive was in use at Fernie, but reading between the lines* it may be assumed that it was gunpowder, and if this guess be correct, then the solution of the problem becomes at once less difficult. The introduction of safety-lamps, in place of open lights, two years ago, without at the same time rigorously excluding such a dangerous explosive as gunpowder, would in his (Mr. Hall's) opinion make an explosion of this character more likely to happen; because the lamps would render accumulations of gas possible, less dreaded, and hence also less guarded against. It is stated that "a considerable amount of gas was produced and could generally be detected."† Now, once accumulations of gas come to be disregarded, and blasting with gunpowder is continued (there was "constant blasting" in the mine‡), it is not surprising if, sooner or later, a flash from a shot reaches one of these accumulations; and such an occurrence in a mine of the character of Fernie (well ventilated and of a specially dry and dusty nature) would almost inevitably give rise to a wide-spreading and devastating explosion.

The phenomenon of coal-dust flaming inside the safety-lamp is a very familar one, but he (Mr. Hall) was not aware that this had ever caused an ignition outside the gauze.

He (Mr Hall) agreed with Mr. Blakemore that it is often most difficult to arrive at anything definite from the signs of passage of flame and force, as they are usually very contradictory in an extensive explosion, and more especially so if coal-dust is the chief agent. In the latter case, the explosion requires somewhat large quantities of air to maintain it, and its violence is probably renewed again and again on meeting with fresh supplies of air from the several airways. Deposits of coke might be found, he thought, on either side of props, as the settlement seems to take place after the blast has passed and when the air is quietly fluttering to rest.

* *Trans. Inst. M.E.*, 1902, vol. xxiv., page 460.

† *Ibid.*, page 451. ‡ *Ibid.*, page 455.

It is interesting to note that in the Fernie explosion, as in many others, nearly all the victims were found in or very near their several working-places. Mr. Blakemore states that "with the exceptions noted hereafter, all the bodies were found in the places where the men were known to be at work, death in every instance having been instantaneous."* Then again, "all the other men, who were killed, were found at or near to their working-places, and most of them had not moved."† Could Dr. J. S. Haldane (who recently reported that nearly all the deaths in colliery-explosions were due to carbon-monoxide poisoning) tell the members whether death from this cause is consistent with (1) the fact of apparent instantaneous death, and (2) with the apparent absolute necessity that this gas would take some time to reach the men working at the far-ends, away from the site of the explosion? During this interval one would naturally expect the men to make an effort to escape. The first instinct of men in a position of this kind is to get together as quickly as possible, and the bunches of men found together have no doubt been poisoned: but the deaths of those found with their picks in their hands, as it were, seem to demand some further enquiry.

Mr. James Ashworth (Derby) wrote that the originating cause of the Fernie explosion, as in many other cases, had been left shrouded in mystery, and Mr. Blakemore suggested three possible causes, namely:—(1) The failure of a bonnetted Clanny safety-lamp; (2) a shot fired in one of the working-places, or (3) gas ignited by some undiscovered cause. Whatever may have been the original source of flame, all the witnesses, at the enquiry, were agreed that the extent of the explosion was due to the presence of coal-dust. Coal-dust is recognized by many mining-engineers as a far more dangerous element of risk, in a colliery, than fire-damp. It has been observed on the American continent that the greatest number of explosions have taken place in bituminous-mines, and that anthracite-mines, which have often from 3 to 4 per cent. of fire-damp passing up the upcast shafts, are not so liable to explosions. Mr. W. D. L. Hardie, of Lethbridge, has stated that all the superior coking-coals produce a dust which has a more or less "greasy" feel, indicating that some of the heavy hydrocarbons of the paraffin series are present in the volatile matter; and that if such coal-seams give off fire-damp, it is very

* *Trans. Inst. M.E.*, 1902. vol. xxiv., page 451. † *Ibid.*, page 452.

likely to be "sharp," indicating that hydrogen, as well as heavy hydrocarbon gases is a possible constituent of the fire-damp. Under these conditions, which, from Mr. Hardie's personal observation, hold good at Fernie, the inflammable point of the explosive gas given off is very much lower than that of ordinary fire-damp; and it can therefore be readily imagined how easily the dust may be raised to an incandescent heat, and the hydrocarbons distilled in quantities large enough to cause an explosion of any magnitude.

Mr. Blakemore, Mr. Hardie and others are in accord with him (Mr. Ashworth), in concluding that coal-dust in the meshes of a safety-lamp may become incandescent almost instantly, and thus pass the flame to the mixture outside the lamp.* The safety-lamp, in use at Fernie, was of the bonnetted Clanny type, probably of the same pattern and make as that used in the fiery mines of this country, and although the cause of the ignition of fire-damp and dust was undetermined, yet we find that Mr. Blakemore formed a strong opinion that the initial cause was the failure of a sound lamp to prevent the flame, of ignited coal-dust and fire-damp within the lamp, from passing through the gauze, and thereby exploding the surrounding atmosphere. The jury also endorsed this opinion by their verdict, namely, "that the safest explosives and most approved safety-lamps be used; and that a more thorough inspection be adopted at these mines, throughout the old workings and rooms contiguous to the air-channel that are not being worked." The jury also found that the initial cause was augmented and intensified by coal-dust. It would appear that the directors of the company also agreed with this view of the cause, because they took out all the bonnetted Clanny lamps and replaced them with Wolf lamps burning benzolene as the illuminant. As to whether the mine is more safely lighted now than it was before the change of lamps, is a subject which might very properly be debated, on the basis of the accidents which have occurred in this country.† The serious point to be considered by engineers is, that there are probably hundreds of thousands of the same type of safety-lamp in daily use in the most dangerous and fiery mines of this country. Many authenticated cases of the failure of bonnetted Clanny lamps, when used under ordinary conditions, are known: and we may, with

* "Improved Safety-lamps of the Davy and Mueseler Types," by Mr. James Ashworth. *Trans. N.E. Inst.*, 1880, vol. xxix., page 145.

† "Failures of Safety-lamps whilst in Use, and some of the Disasters caused thereby," by Mr. James Ashworth, *Transactions of the Manchester Geological Society*, 1900, vol. xxvi., page 519.

advantage, closely and dispassionately take the lessons into more serious consideration than they have heretofore received. Some of the best-known failures of bonnetted Clanny lamps in this country occurred at Allerton Main in 1894, Shakerley in 1895, Universal colliery in 1901, and Abertysswg (Tredegar) in 1902. In all these cases, the only source of flame was a safety-lamp of the bonnetted Clanny type, and the lamps were all exposed to mixtures of coal-dust, fire-damp and air, but in no case were the lamps on examination and experimental testing found to be deficient. None of the lamps were, however, submitted to experiments in which coal-dust formed a factor. The importance of submitting safety-lamps to tests in which coal-dust is a factor will be more readily realized when it is remembered that the particles of coal-dust floating in the air-current are so small that they will easily pass through a standard mesh, and if brought into a state of incandescence within the lamp will pass outward in a stream of fire. The ignition-point of such fine coal-dust is lower than that of fire-damp, and therefore mixtures of fire-damp and coal-dust become more dangerous than fire-damp by itself.*

Other influences which may have affected the initiation and extent of this explosion were:—(1) It occurred whilst the second shift of coal-getters, which commenced at 3 o'clock, was at work; (2) the district in which the explosion occurred was described as the dirtiest and dustiest of any of the mines at Fernie; (3) the barometer would probably stand at from 25 to 26 inches only (due to the height of the mine above sea-level); (4) blasting with powder was allowed; (5) local explosions of coal-dust had often been caused by shots; (6) electricity was extensively used for hauling and pumping, and live and bare wires were carried along the haulage-plane at 250 volts; (7) the electric locomotives, which hauled the trams out of the mine, ran for some considerable distance in the return-air, and electric Tripley pumps were also placed in the return-air; and (8) the roads were watered, and in some places naturally wet.

It would be recognized, therefore, that, in addition to the possible failure of a bonnetted Clanny lamp, electricity was a dangerous source of ignition, if, as from the suggested neglect in shutting a door, the air became charged with fire-damp and then came into contact with the sparks from a motor, or sparks between

* "Improved Safety-lamps of the Davy and Mueseler Types," by Mr. James Ashworth, *Trans. N.E. Inst.*, 1880, vol. xxix., page 145.

the connecting arm of the locomotive and the live wire placed close to the roof of the haulage-road, or if a short circuit were possibly formed by a dense cloud of dust constituting a bridge between a bare wire and the rails, floor or roof.

The writer would like to hear from Mr. Blakemore what sort of stoppings were placed between the old gob and the working-faces, and on either side of the main haulage-road, all of which are stated to have been blown out. From the description, it would appear possible for a large fall of roof in the goaf or back workings to have forced out gas at a high velocity into the ventilating current, and thus have been a main cause of the explosion, no matter how the gas became ignited.

One very interesting feature, of which he (Mr. Ashworth) had observed strong evidence in very many explosions in this country, was the instantaneous effect of an explosion on all parts of the mine, often setting up so sudden a percussion of the atmosphere that effects had been produced similar to those which Mr. Blakemore described as universal ignition, concussion and local explosions. At Fernie mine, the evidence of Burrows, who escaped from the No. 3 mine, is confirmatory: he heard no noise, all the candles went out, he felt a pressure as if his head would burst, and afterwards within 50 or 60 feet of the entrance of the mine he put out his hand to save himself from falling, and found that the dust was so hot that he thought his hand was burnt.* The point where this dust was so hot was 3,000 feet from the supposed point of origin, and where there was a considerable quantity of water. This is another proof that wet roads will not isolate an explosion in one district of a mine from communicating the effects to another district, without the flame of the originating explosion actually passing over the intervening space. The instantaneous nature of the explosion is also evidenced by the fact that the men were killed without moving from their working-places, by concussion of the brain, and burned by the sudden percussion of the air. The earliest recognition of the effect of percussion on parts of a colliery remote from the place of origin, will be found in Mr. Joseph Dickinson's report on the Udston explosion, and this effect was also in very distinct evidence in the explosions at Llanerch, Tylorstown, Albion and Universal collieries.

Depositions of coal-dust on props and other surfaces, as an indication of the direction in which the flame of an explosion first

* *Trans. Inst. M.E.*, 1902, vol. xxiv., page 452.

passed along a roadway, is also a very interesting subject; and although very contrary indications are often discovered, it appears probable from Mr. W. N. Atkinson's report on the Talk-o'-th'-Hill explosion, 1901, that the face of a prop on which a pyramidal streak of dust is found may be assumed to be the side which faced the blast, and that the more diffused deposit on the opposite side is outbye from the point of origin: but charred dust is nearly always found on the side of the prop that was not facing the blast.

Mr. Blakemore supports his (Mr. Ashworth's) old contention that watering is at the best only a sanitary precaution in a fiery and dusty mine, and that it cannot and never has limited an explosion to one district, because it has no power to reduce the percussive effect of an explosion. He (Mr. Ashworth) also believes that the immunity of the No. 2 mine at Fernie, from previous disaster through shot-firing, has been due to the very cold and dry nature of the air-current, which, at the high altitude of 3,000 feet above sea-level, is its natural condition. The futility of depending on water as a safeguard is easily realized, by noting that 5 per cent. of water-vapour is required to be present to obtain the maximum effect from an explosion, and yet it is not possible to put more than about 3½ per cent. into any mine-current. Watering, therefore, adds to the explosive effect, instead of decreasing it. This fact was distinctly demonstrated in the case of the explosion at the Universal colliery, where the air-current from the York district was practically saturated with moisture, and yet the whole of the latter district was traversed by flame.

Mr. H. W. G. Halbaum (Gateshead) wrote that he had read Mr. Blakemore's paper with great interest, and had no hesitation in stating that the Fernie explosion was a typical example of what was usually called a "coal-dust explosion." He was also of opinion that it was brought about without the initial assistance of "gas" in the mine-atmosphere, at any period immediately though appreciably previous to the catastrophe. He thought that the theory of such explosions would have a wider and more beneficent practical result if the theory were more easily appreciated, and rendered capable of more rapid propagation. And he believed that one important step in that direction would be made if the nomenclature of the theory were overhauled and revised to some extent. They continually spoke of a "coal-dust explosion." Many of them knew exactly what was meant by that term; they knew that

it stood for a certain series of phenomena, and they also knew that the term entirely failed to describe such phenomena—they knew, in fact, that it was a misnomer. They also spoke of such an explosion occurring in the absence of gas. An experienced miner might interpret that expression in the light of his mining idiom, and possibly unearth the true idea underlying the phrase: but a person ignorant of mining idiom, however highly educated otherwise, could hardly be expected to extract any grain of truth from so entirely false a representation of the real phenomena. As a matter of common knowledge, they had the typical explosion of gas, and they had the typical explosion of coal-dust; but, strange to say, it was a matter of scientific fact that the typical coal-dust explosion was, in general, a greater explosion of gas than the typical gas-explosion. Similar anomalies often appeared in the nomenclature of comparatively new theories. The earlier investigators named the phenomena which they imagined to occur; the later enquirers retained the names for the phenomena actually found taking place, with the result that a greater or lesser crop of misnomers survived in the final nomenclature of the theme. In some cases, the retention of those misnomers did no great harm; in other cases, they became appreciable obstacles to progress, and he (Mr. Halbaum) thought that the misnomers in the nomenclature of the coal-dust theory distinctly belonged to the latter class of cases; wherefore, in his opinion, it was essential to replace them by names that more truly described the entities which they were supposed to represent.

He thought that there would be little or no difference of opinion as to which class of explosions the Fernie explosion belonged, and he would therefore confine himself to the discussion of some of Mr. Blakemore's conclusions and suggestions. Mr. Blakemore cast doubt upon the efficacy of watering as a preventive of coal-dust explosions. The Fernie explosion, however, could scarcely be said to justify that doubt, for Mr. Blakemore stated that the watering adopted in the Fernie mine could not be claimed as thorough or satisfactory in any sense. A chain was no stronger than its weakest link, and evidently that link at the Fernie mine was very weak indeed. The explosion was evidently initiated by the gunpowder shot fired in the cross-cut near the face of No. 1 machine-room. If it could be shown that the watering in the vicinity of that shot had been thoroughly and systematically done, Mr. Blakemore's position would have received some support, but all the evid-

ence seemed to point the other way. The fact that the explosion, once started, passed over considerable wet areas in other parts of the mine, proved nothing more than what might easily have been foreseen. The inflammable constituents of the coal-dust, the heat generated by previous explosions, the accessibility of fresh oxygen, etc., on the one hand, and the extinguishing power of the wet areas on the other hand, were, after all, merely the components of the resultant force which enabled the blast to traverse those areas without extinction. The stronger force would, of course, be more nearly reproduced in the resultant than would the weaker. According to Mr. Blakemore's account, the coal-dust was in extraordinary abundance; the ventilation also appeared to have been ample; the combustion must therefore have been maintained with extraordinary severity, and it was little wonder that such a force should successfully pass right through watered areas that might easily have interrupted and quenched a less violent blast. At the Fernie mine, the great mistake lay in not thoroughly watering the ground in the immediate vicinity of the shot. At that initial stage, the destructive power might have been conquered and rendered innocuous in its infancy by simple means, which, however, would be totally inadequate to cope with the accumulated energy of the destructive power at the later stages of its passage through the mine. In his opinion, it would be soon enough to condemn the system of watering after they had given it a fair trial. At the Fernie mine, it had not received a fair trial, and the system adopted was, according to Mr. Blakemore's account, neither thorough nor satisfactory.

Mr. Blakemore's second suggestion, with respect to the action of coal-dust upon a safety-lamp, might be met by the reply that in the event of any explosion within a safety-lamp, the force of the explosion would be limited by the quantity of oxygen within the lamp as well as by the quantity of explosive substance therein, and it would also be limited by the degree of combustion attained. In the case of coal-dust exploding within a lamp, his (Mr. Halbaum's) opinion was that the combustion would be less complete, and the explosive force therefore less powerful, than if a pure and perfect gas had been exploded; and, therefore, in his opinion, the margin of safety obtained by any lamp in the presence of coal-dust was, if anything, greater than the margin of safety obtained by the same lamp in the presence of gas. The principles which governed (and generally also prevented) the passing of flame from the interior of

the lamp to the external atmosphere were, of course, the same in both cases. He was, therefore, inclined to think that the Fernie explosion raised no special question with regard to safety-lamps, such as Mr. Blakemore had suggested.

He was also afraid that he could not agree with Mr. Blakemore's third conclusion, to the effect that blasting should be abolished in dry and dusty mines, apart altogether from the question of gas. His idea of the necessities of the case, however, practically came to the same thing as Mr. Blakemore's idea. His (Mr. Halbaum's) idea was that, not the blasting, but the dry and dusty mine should be abolished. Let the dust be removed, and let the dryness be destroyed by proper watering in the vicinity of all shots. If this were done in any mine, they could continue blasting, but the blasting would never take place in a dry and dusty locality. In many mines it would pay them infinitely better to destroy the dryness and the dustiness of the blasting-sites rather than to abolish the blasting itself. He fully believed that blasting could be safeguarded with success. In addition to the means that he had mentioned, a competent person should be appointed as shot-firer and blasting superintendent. That competent person should not be merely any person who could detect gas; he should understand blasting operations; he should be empowered to condemn any drill-hole not to his liking; and he should also determine the amount of the charge. Any person unable successfully to undertake such duties was unfit to be a shot-firer, and any manager appointing such persons as shot-firers incurred serious responsibility. With the appointment of competent shot-firers, the removal of coal-dust, and the thorough watering of the ground in the vicinity of the shots, he was strongly of opinion that blasting in all mines might be made as safe as blasting in open-air quarries. He granted that a coal-dust explosion, once initiated, and gathering strength *en route*, was a very difficult matter to stop: but he submitted that the prevention of the initial explosion was a very easy matter—at all events, he had yet to hear of the explosion that had occurred where all of the precautions which he had mentioned were faithfully observed.

He agreed with Mr. Blakemore in thinking that the effects of violent concussion in agitating particles of coal-dust might be very serious indeed, although Mr. Blakemore and himself viewed the matter from somewhat different standpoints. He (Mr. Halbaum) did not think that those aerial concussions which Mr. Blakemore

had in view could, taken alone, have any appreciable influence in heating the dust to any dangerous degree. The real danger of a cloud of dust, as opposed to a mere heap of dust, lay in the immense area of exudation thereby offered to the gases occluded in the dust. A simple calculation would show that 5 cwts. of coal, pulverized to cubes having an edge of 0·01 inch, and suspended as a cloud in the air, exposed an area of exudation equal to a longwall-face 3 feet high and 3 miles in length. When they remembered that the same weight of anthracite-coal, raised to the temperature of boiling water only, would expel 50 cubic feet of its occluded gases, the possibilities of the case at once assumed alarming proportions. Let them imagine a blown-out shot to raise that quantity of dust as a cloud in the atmosphere—a very possible case where, as in the Fernie mine, the coal-dust was only removed when it became an impediment to haulage. In such a case, they had at once an immense area of exudation, a temperature more than sufficient to produce a sudden evaporation of the occluded gases, and possibly a temperature or a residue of heat, sufficient to ignite the gases thus suddenly liberated. Whether the last-named effect was produced would depend on the quantity of the charge blown out, and upon the amount of work done by the charge before being blown out. For these phenomena, like all other physical phenomena, were amenable to the principle of work; and that being so, they would see the necessity of having competent shot-firers, men of practical experience and ability, able to so order the placing of shot-holes and charges as to ensure, so far as human skill could ensure anything, that the energy of the charge should be expended in the shot-hole and not outside of it. But even in the contingency of a shot being blown out, the removal of the coal-dust from the vicinity, and the thorough watering of the ground in the vicinity of the shot, should save the situation. The distant coal-dust might be agitated by the aerial concussion, but the matter would end there—the heating effects, so far as the dust was concerned, would, in all probability, be practically, if not absolutely, *nil*.

The CHAIRMAN (Mr. J. S. Dixon) moved a vote of thanks to Mr. Blakemore for his interesting paper.

Mr. P. KIRKUP seconded the resolution, which was cordially approved.

Mr. P. KIRKUP read the following paper on an "Improved Railway-rail Fastener":—

IMPROVED RAILWAY-RAIL FASTENER.

By PHILIP KIRKUP.

The very large and increasing railway-traffic of the present day makes the subject of any improvement in the method of securing the rails to the chairs and sleepers of the permanent way of the utmost importance to all concerned. From both an economic and humane standpoint, an appliance giving greater security and safety should be gratefully received by the owners of rolling-stock and the travelling-public generally.

It will be generally known that the ordinary double-headed rail and also the bull-head rail, which are now more generally used by the various railway-companies in this country, are each secured to the chairs by means of an oaken key driven longitudinally between the rail and the outer jaw of the chair. This method of fastening these sections of rail is almost universally adopted, and it will be admitted by engineers and inspectors that its most serious drawback is the liability of the key to become loose and to slip out, owing to the constant vibration caused by the passing of trains over it. Large numbers of men are continually employed on public railways in examining the permanent way and re-adjusting such keys as have become displaced during the interval between each inspection. Another serious source of danger and anxiety is the shaking loose of the keys and fastenings at points and crossings where greater lateral strains arise and liability to derailment is imminent. The danger is more to be feared in summer, owing to the pining of the wooden keys, and consequently greater vigilance has to be observed in keeping them in position so as to secure the maximum of safety.

The cost of maintenance of the fastenings on private railways through workmen and others picking up the displaced keys and taking them home for firewood is an item of some moment. From actual experience, the writer can state that renewals from

this cause are frequent and expensive, more especially where the colliery-owner has a long length of railway to maintain between the pits and the shipping-staithes.

After a considerable number of experiments, the writer has been enabled to arrive at a practical solution of the difficulties enumerated above, and has now pleasure in bringing forward for consideration an entirely new method of fastening the rails to the chairs. This consists of the substitution of a cast-iron or steel wedge and a small hard wooden cushion, for the ordinary key. The wedge has a double flange on each vertical edge, so that when driven downward between the outer jaw of the chair and the wooden cushion, the rail is held secure. The cushion is made of oak, and of a size sufficient only to be embraced by the

FIG. 1.—THE IMPROVED IRON WEDGE APPLIED TO STRAIGHT RAILS.

inner flanges of the iron wedge, and thus it is retained in position to act as a buffer and to meet the unequal expansion and contraction between the steel rail and the cast-iron chair. The outer flanges of the wedge also embrace the jaw of the chair.

The arrangement can be applied to existing chairs, and has the further recommendation of being inexpensive in primary cost and maintenance. The wedges, when driven down with a light hammer, completely secure the rails to the chairs, and, being fixed vertically, cannot shake out of position so as to render the rails at any time insecure and unsafe.

The writer may mention that the engineers of the North-eastern Railway Company have, during the last few months, severely tested the new fastener on lines near the railway-stations at Newcastle and York; more recently a section of the Team

Valley main line has been laid with it, and so far they express themselves as being thoroughly satisfied with the utility of the invention.

Fig. 2.—The Improved Iron Wedge Applied to Crossings.

Figs. 1 and 2 illustrate the application of the iron wedge and wooden cushion.

Mr. A. L. Steavenson (Durham) remarked that several methods had been tried for improving railway-chairs and fasteners, and a successful method had been recently adopted in Cleveland; the invention of Mr. W. Walker, who had adapted to the railway-chair the principle of the safety over-winding hook. Wood was apt to pine and fall out, and it might be pulled out by any persons mischievously inclined, but with Mr. Walker's clutch no wood was required, the rail had a longer life, because it was held in such a position that it met the pressure of the wheel, and instead of the rail wearing down on one side it wore in the centre. It was no heavier than an ordinary chair, and any vibration only tended to hold the rail faster, and chocks could only be removed by removing the rail.

Mr. CHARLES A. HARRISON (North-Eastern Railway, Newcastle-upon-Tyne) wrote that he considered Mr. Kirkup's rail-fastener was a very good one, but he could not agree with his conclusion that it would save any labour, because whatever rail-fastener or key was adopted the men would still have to inspect their lengths of railway twice a day, and other considerations would forbid the increase in the length of line of which each gang of three men are supposed to be in charge.

Mr. KIRKUP pointed out that his paper merely described a fastener adapted to the existing railway-chair, and was not a new form of chair, as in the case of the Walker clutch. As regards the adoption of steel throughout, in preference to cast-iron and wood, it was considered that greater security was obtained by using a soft material like wood which would allow of greater freedom of expansion between the steel rail and the cast-iron chair.

Mr. J. K. GUTHRIE (Preston) asked whether vibration caused the iron wedge to creep upward.

Mr. KIRKUP said that, in practice, the surface of an ordinary casting was sufficiently rough to grip the timber, even without the tooth, which, however, was provided. After a practical test of the cast-iron wedge at the Central Railway Station, Newcastle-upon-Tyne, where many hundreds of trains were passing over the rails every day, the engineer to the North-Eastern Railway Company had quite recently laid down ½ mile of track with the new fastener on the main line to London, and it was standing the test most admirably.

The CHAIRMAN (Mr. J. S. Dixon) proposed a vote of thanks to Mr. Kirkup for his paper.

Mr. M. WALTON BROWN seconded the resolution, which was cordially approved.

Mr. W. C. BLACKETT read the following paper on "Underground Stables":—

UNDERGROUND STABLES.

By W. C. BLACKETT.

Much interest was shewn by members in their discussion upon a recent paper concerning the feeding of colliery-horses, and it is possible, therefore, that the subject of stabling may attract equal attention.

Moreover, it may be advisable to shew that mining-engineers do give some thought to a subject which has recently engaged the consideration of several well-meaning persons, who without having any adequate means of informing themselves, have arrived at the conclusion that the treatment of pit-ponies deserves more of their sympathy than does that meted out to other people's horses. There is more cruelty and neglect on the surface than is to be found among the pit-lads of Durham and Northumberland, among whom it is, in the few instances discovered, severely punished. Cruelty is an extravagance which even the callous cannot afford.

On the writer's desk is a polished hoof, the silver-mounted inscription of which reads as follows: -

SWALLOW.

A 10 hands Shetland pony, was 5 years old when put to work down Kimblesworth pit on May 2nd, 1876. He ceased work 20½ years later on October 12th, 1898, aged 27 years. During the whole of his working life he never had a sick or sorry day, the 6 weeks' strike of 1879 and the 13 weeks' strike of 1892 being the only occasions on which he was idle. On August 8th, 1895, when 25 years old, he took third prize among 20 other pit-ponies shewn in Durham.

This is but typical of many examples which could be brought forward; and every colliery can usually boast of several animals whose life-records would speak equally well of honourable years of comfortable equine servitude, and of the kindness and humanity not only of those who manage the mines, but of the men also who wait upon the ponies in their stables and the lads who direct their labours in far-reaching underground galleries.

In no way can the comfort of a pony be better provided for, than in the home to which it has to return after its day's arduous labour is finished, and for this it must look very largely to the management of the colliery.

Horsekeepers may be anxious about the welfare of their charges, and may strive their best to attend thoroughly to their watering, feeding and cleaning, but the work will only be well done if the stable-arrangements are such as lend themselves naturally to such care and cleanliness.

The writer has seen all kinds of underground stables, from those extravagant in their cost, lavish in brick-arching and in many fancy contrivances, to those of a most primitive and ill-conceived design, but that which commends itself, is one which combines simplicity and economy with hygiene and comfort.

The ventilation should be so arranged that air cannot be wasted to the return-airway, and therefore the stables preferably should be placed as a branch-airway from the intake-airway, having the entrance and exit so constructed with "sconces" as to catch enough current to freely circulate through the stables, without unduly chilling the inmates, and return the air for further use in the mine.

Figs. 1, 2 and 3 (Plate XIII.) shew how the stable should be made. The gallery chosen should be lined on each side with brick-walls, AA, BB, in which any recesses, required for a variety of purposes, can be made where necessary. The leather-gear, however, is better preserved if left hanging in the air-current.

These walls may support, if the roof requires it, wooden or steel joists, C, which may be placed so as to mark the divisions between each stall. If the roof is very bad, arching sprung from side to side of the gallery may take the place of the joists. Hung from these joists or from the roof by means of chains, are swinging wooden partitions, D, which separate the stall of one pony from that of its neighbour. The moving partitions have the advantage that, while amply providing for separation, they permit free ventilation, and do not furnish any fixed corners for the accumulation of dirt or for the harbouring of vermin. Impatient animals cannot hurt themselves or their stables by kicking at sides which swing and give to the blow, while the gregarious nature of the horse is provided for by allowing him a view of his companions

on either side. The whole stable can be seen at a glance from one end, and is invariably sweet and free from strong ammonia vapours. In any form of stable it is necessary to move quarrelsome animals until a neighbour to their liking is discovered.

The mangers are fashioned in cement, and supported by means of brickwork, E, at a height appropriate to the size of the animal. They should be as low as possible, and the writer thinks that the mangers shewn in the illustrations would be much improved by being placed lower. Iron bars, built in a few inches from each edge, will prevent the ponies from throwing out their food and wasting it. Water can be brought to each stall by means of an iron pipe, and each receptable should be provided with easy means of drainage for cleaning-out purposes. Horses thrive better if they have access to water at all times, and do not drink so much as when it is only given at long intervals.

An iron rack should run along the front-wall for the use of grass in summer, as it is to be presumed that hay will always be given chopped.

A large ring in the front of the manger with a weight, chain and collar, will serve to fasten up the horse, and great care should be taken that the chain is of a proper length. On no account should any animal ever be tied up without a running chain and ring, as in this way accidents occur from strangling, the horse getting his leg over the chain or rope and being cast in his stall.

The floor of the stable is the most important feature, and the writer has come to the conclusion that there is only one really good method of construction, in the absence of ordinary bedding material. Mr. Charles Hunting, in his paper on the feeding of underground horses, is responsible for the statement that only 1 in 10 lies down on brick, 2 in 10 on cement with sawdust, and 7 in 10 on wood. This, the writer thinks, can only refer to very large horses as he is not aware of a single case at the collieries under his charge of an animal which does not regularly lie down. The floor of each stall is made of the best possible cement-concrete, channelled in the ordinary way, with a fall of about 1 in 30 to a main-drain behind the stalls, having a fall of about 1 in 48. The concrete of each stall is further recessed, so as to contain a boarding of pitchpine, 5 feet by 6 feet by 1¼ inches thick, with ¾ inch interstices between the boards, and on these the ponies lie, high and dry.

The boards are made in halves, and are daily lifted for airing and cleaning, while the pony is out at work. The slope of 1 in 30 for drainage is not good for the flexor-tendons or hind-quarters of a horse, and it is possible to correct this by the use of boards, so that the horse may stand practically level thereon, while the cement below remains sufficiently sloped.

Actual experience has proved that such a floor lasts longer than any other, and that the condition of the ponies is much improved. The pitchpine lasts far longer than cement, under the wear of iron shoes, and floor-boards are still in use which were laid down when first designed some 5 years ago.

Another form of stall, shewn in Figs. 4 and 5 (Plate XIII.), is used where the roof is very short and would not allow of the excavation of a wide gallery. Each stall is really a loose-box, but in other respects the construction remains the same.

If possible, stables should be lighted by electricity, and kept whitewashed and disinfected. A curious belief has sprung up that dark stables injure the eyes of horses. It is a common fallacy that animals working underground become blind, and even so admirable a writer on the subject as Mr. James Fitzwygram says that if deprived of light, the optic nerve becomes paralysed and blindness results. This is all nonsense, although of course if a horse were never allowed to see, something of the kind might happen; yet, under ordinary working conditions, neither the eyes of men nor horses are affected by working underground, other than by injury.

The pony that has been referred to as working over 20 years underground, was quite sound in his eyes, and exemplified the writer's invariable experience.

The cost of such a 14 hands pony-stall as has been described would vary, according to requirements, from £5 to £6 10s., but this does not include any stonework or other excavation.

One or two loose boxes for isolation-purposes should be provided, in positions where infection of healthy animals would not be easy, and any pony coughing or showing symptoms of even common cold should be removed thereto at once. These boxes

should be fitted with slings for severe injuries, as in winter time it is usually inadvisable to remove a pony from the warm mine to the cold surface.

Further hospital-accommodation should always be provided on the surface, and no newly-purchased animal should ever be put underground, until it has been under careful observation in an isolated place for one or two weeks.

Mr. H. R. Hewitt (H.M. Inspector of Mines, Derby) said that horsekeepers were too frequently labourers, who knew little of the requirements of a stable, and were not trained in stable-management, with the consequence that horses at some mines were neglected. Stables should have a tram-road at the head and at the tail of the horse, the former used entirely for feeding purposes and ventilation, and there was then no necessity for the attendant to go by the side of a restive horse, except for the purpose of cleaning the horse or the stall. When there were two roads, there was ample room for a good air-current to pass along each standing, and there was no necessity for the wooden partition, and he preferred to see each standing kept separate and distinct by brickwork.

It was not always possible to light stables electrically, but it was always possible to keep them whitewashed and disinfected. Unless several sets of stables were built some distance apart, it was very desirable that several loose boxes should be provided, for the isolation of infectious and supposed infectious cases. The horse was particularly liable to infection from its neighbours in the stable. All stables should have an ample volume of air passing through them, and should be kept strictly clean in every way, but he (Mr. Hewitt) was surprised to find that Mr. Blackett recommended that the air-current, after passing through the stables, should go straight into the mine-workings. In the Special Rules for the Midland mines-inspection district, this was prohibited, with the words "where practicable" added, and it was very desirable that stable-smells should not be allowed to pass along with the air-current and into the working-places. It was absolutely necessary in the majority of cases to avoid this, and the passage of ventilating-current direct into the return air-way was an easy matter in most mines.

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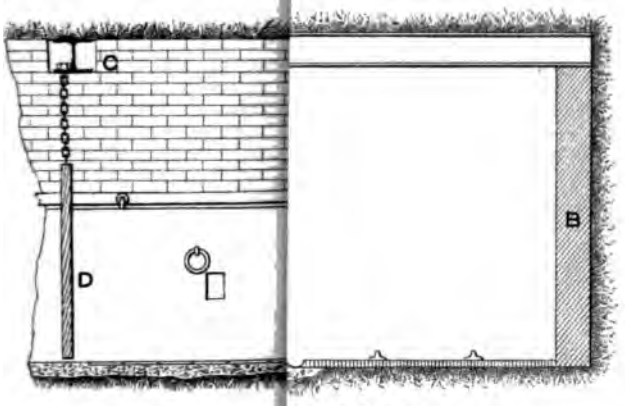
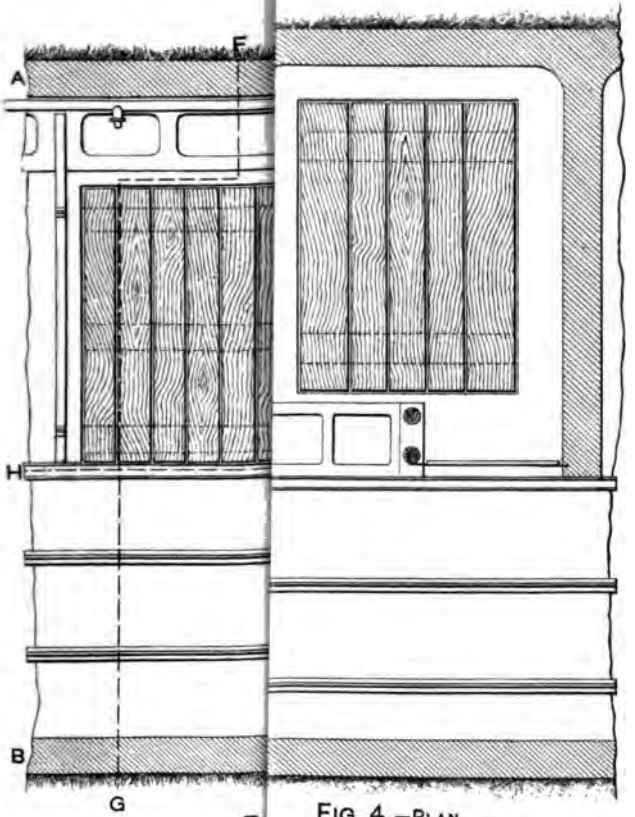


FIG. 2.—SECTION T INE F G OF FIG 1.



F FIG. 4.—PLAN

Mr. H. W. Hughes (Dudley) wrote that there were several points in Mr. Blackett's paper about which differences of opinion might reasonably exist. It certainly appeared preferable to ventilate the stable by an independent split of air and to return the more or less foul air direct to the upcast, without attempting to pass it into the workings. This split of air could be properly controlled by a regulator, leakage could be reduced to a minimum, and a smaller or larger quantity of air passed through the stables as desired. He preferred to send a moderate quantity of air through the stalls as soon as the horses had left in the morning, so as thoroughly to cool, purify and clean the stables, until they were quite sweet. The regulator was then nearly closed, and the stables allowed to warm again, ready for the horses at night. He had found that it was not advisable to send horses direct from the workings into a cold stable, but to bring them in warm and then slowly allow them to cool down. The question as to whether the stable should be placed in an elaborate arch or not was dependent upon circumstances, and it was the misfortune and not the fault of the engineer that he had often to waste money on brickwork. He had at one colliery a stable-arch inverted, the brickwork of which was 23 inches thick, but this was only put in after two other arches with thinner walls and inverts had been crushed. Mr. Blackett's statement that horses throve better if they had access to water, at all times, was an important one, and he believed that it was fully borne out by facts. He had always used a water-bosh to each stall, supplied by a pipe and provided with an outlet-drain at the bottom: this was generally closed by a plug, which enabled the stay of water to be let out each day.* In addition to ensuring a supply of fresh clean water, he also flushed out the stall, and this rendered cleaning more easy. Swinging partitions had all the advantages claimed by Mr. Blackett, but some of them were shared by fixed partitions. There was no need for a fixed partition to reach the floor or the roof: it might occupy the middle part, and then the ventilation was not impeded, there were little or no places for rubbish to accumulate, and each horse could see its neighbour. Sometimes with a swinging partition, he had found horses injuring themselves about the head by getting up awkwardly, and as a horse generally lay down on the same side each night he sometimes

* *Text-book of Coal-mining*, fourth edition, page 233.

pushed the partition on to his neighbour. Again, although they could not directly kick the next horse yet they could kick the partition on to him, and as it rebounded they also received a blow; and this often caused restiveness among the horses. The description which Mr. Blackett gave of the double flooring that he had adopted was most interesting. Everyone would admit that in the absence of bedding, which was rather out of place under ground, a horse would lie down better on wood than on any other material, but, unfortunately, wood-flooring became saturated with water, polished and slippery, making it a most difficult surface for horses to stand upon. He had tried fixing small wooden strips, in order to afford a foothold to the horses, but these sometimes were kicked off, and at others had the corners filled with dirt, so that they became useless. Such wooden casings were fixtures and placed directly on the ground, but by making the floor in two halves, so that it could be moved, and by elevating it slightly above the concrete-floor, Mr. Blackett seemed to have overcome these objections.

Mr. W. C. Blackett said that he once had been carried away with the idea that stables should have tram-roads at the head and tail, and several other adornments such as expensive brick-partitions. Experience, however, had taught him that much of this was unnecessary and a waste of money; there were far too many corners to harbour dirt, and perfect airing was an impossibility. He could not agree with those who had framed the Special Rules in the Midland mine-inspection district, so as to prevent the air from the stables being returned for further use into the mine. Horses and ponies did not breathe, while resting, say, more than 90 cubic feet of air each per hour, and to keep a stable of, say, 50 animals cool, it was necessary to circulate many times this volume. The ventilation of a mine contemplated the provision of air for men and animals, and while they were working they used much more air than when resting: yet if it was not considered objectionable to use air which had passed over the ponies in the workings, why should it not be allowed for important purposes after it had served the ponies, using as they did a less quantity when at rest? The most important purpose to be served by air in a mine was to "dilute and render harmless noxious gases," and to waste large quantities of air, merely because a small percentage

had once been breathed by ponies, seemed to him to be folly. Allowing that the small quantity of carbonic acid so produced was harmless, Messrs. Hewitt and Hughes would be in a further dilemma, inasmuch as if the stable-air was unfit for further use in the mine, then the stables must have been allowed to become too foul. The air-current, on the in-bye side of stables kept in a proper state, should have only a perceptible odour, and that largely from the use of small quantities of disinfectant. In those stables, where the current was wasted into the return-airway, he had observed certain incidents at nameless collieries, which introduced further objections. He had, for instance, known cases where a sort of war was carried on between the overman who wanted air for his workings and the horsekeeper who desired it for his animals. Sometimes the workings were foul, and sometimes the horses suffered.

A cold was almost an unknown thing in the stables under consideration, and, when such a thing had occurred, the animal was at once isolated, and seldom indeed had it ever happened that the complaint spread. Horses caught cold much more readily in dirty, close stables than in those that were well-aired, and for that reason he could not agree with Mr. Hughes, who apparently wasted most air in the day-time (when he presumably wanted it the most) by allowing more air to pass the stable-regulator when the ponies were out. And, in any case, the ventilation could be quite as easily controlled in returning the air to the mine, as in wasting it to the upcast shaft.

The CHAIRMAN (Mr. J. S. Dixon) moved a vote of thanks to Mr. Blackett for his interesting paper upon an important detail of mine-management.

Mr. M. WALTON BROWN seconded the resolution, which was cordially approved.

DISCUSSION OF MR. SYDNEY F. WALKER'S PAPER ON "ALTERNATING CURRENTS, ETC."*

Mr. G. W. de TUNZELMANN (London) wrote that Mr. G. A. Mitchell said "he had seen it stated that while a pressure of 1,500 or 2,000 volts was fatal to life, with much higher pressures, such as 10,000 or 20,000 volts, there was not the same risk,"† and

* *Trans. Inst. M.E.*, 1901, vol. xxi., page 451; and vol. xxii., page 566.

† *Ibid.*, vol. xxii., page 569.

asked for further information on this point. It appeared obvious to him (Mr. de Tunzelmann) that what was in Mr. Mitchell's mind must have been some statement referring to a fact which was well known to most station-engineers and others who had to deal in practice with high-pressure alternating currents, namely, that a voltage of about 2,000 was very much more dangerous to switch-board attendants and workmen than those of 10,000 volts or upwards. The reason for this lay in the fact that if a man accidentally grasped a conductor, contact with which would include him in an alternating circuit with a pressure of, say, 2,000 volts, he would feel little effect until his hand was actually in contact with the conductor, when the resulting contraction of the muscles would prevent him from letting go, ensuring the best contact possible under the circumstances, and the prolonged action of the current. At 10,000 volts, and still more at higher pressures, the hand would be strongly repelled before actual contact took place, to such an extent that contact was extremely unlikely, and, therefore, the workman might very possibly escape with a severe burn, due to a momentary arc being formed between his body and the conductor. If actual contact took place, the hand would be fixed round the conductor as in the case of lower voltages, and, given similar conditions with respect to the two contacts necessary to complete the circuit, a greater current would pass in the case of the higher pressures, and therefore there would be a still greater probability of a fatal result.

Mr. Sydney F. Walker (London) wrote that he could hardly agree with the view set forth by Mr. de Tunzelmann, nor did he think that the experience which he gives is a common one: he would call it a most uncommon experience. His experience, and, he believed, that of most electrical engineers engaged in practical work, is that the current, on touching a conductor, is felt immediately, unless the hand has matter on it which protects it. He had received many smart shocks from a 200 volts alternating circuit, and with a very slight touch. Also supposing that a workman's hands were protected by caked dirt, or horn, so that he would not feel comparatively low pressures, higher pressures, up to a certain figure, would only have the same effect upon him as lower pressures have upon individuals not so protected: this would apply to what may be termed "low high pressures," those of, say, 500 to 2,000 volts. The greater number of fatalities from

2,000 volts circuits have been among workmen. There is one point in connection with this matter, on which Mr. de Tunzelmann is correct, and that is the time-factor. Time, it is now well established, has a most important bearing upon the result, and if a man does catch hold of a 2,000 volts service, it is quite correct to say that he cannot easily let go and is killed by the passage of the current for a given time. But this is also true, in many cases, of a 500 volts continuous-current service, and of a 200 volts alternating-current service. It is hardly correct to say that the 10,000 volts service would repel a man's hand; but it will come out to him, and give him a nasty shock, accompanied by an equally nasty burn, without the necessity of his touching the conductor. Surely that can hardly be called safer. The meaning of this is, with 10,000 volts alternating, the maximum pressure of which is 14,400 volts, the pressure is sufficient to enable the spark to pass across a short interval between the conductor and a man's hand. The high pressure breaks down the resistance of the air-space. So far as he knew, the only possible explanation of the report referred to by Mr. Mitchell, that high pressures are safer, is the fact also referred to at Glasgow, that high pressures are perfectly safe, provided that they are alternating, and at very high frequencies. He (Mr. Walker) might mention that alternating currents of very high pressure and very high frequency are being used in London for medical purposes—in the treatment of cancer and some other diseases. The pressures used cannot be less than 100,000 volts, and the frequencies probably several millions per minute, as against the 2,400 per minute, or 40 periods per second, of modern alternating-current practice.

DISCUSSION OF MR. A. RATEAU'S PAPER ON "A REGENERATIVE STEAM-ACCUMULATOR, ETC."*

Mr. A. Rateau wrote that steam-engines, working intermittently, such as winding-engines and rolling-mill engines, even when they are provided with condensers, consume a very large quantity of steam, the consumption being often four times as great as that of an engine working continuously. The principle of the Rateau system is to fit engines working intermittently with a condenser and to cause the steam that enters the latter to do

* *Trans. Inst. M.E.*, 1901, vol. xxii., page 613.

work in a turbine, regulating the flow of steam by interposing between the turbine and the intermittent engine, an apparatus which can be called a steam-regenerator.

Taking as an example, the plant nearly completed at the Bruay mines, the steam-regenerator consists of 3 vertical cylindrical vessels of wrought-iron, within which are placed a series of cast-iron plates, the upper portions of which form a bason. These vessels communicate on one side with the cylinders of the winding-engine and on the other side with the turbine. When the winding-engine is at work, the steam enters the regenerator in quantity greater than the mean consumption of the turbine; and the excess is condensed in the cast-iron basins by reason of a slight increase of pressure within the apparatus, a pressure practically equal to that of the atmosphere. The temperature also rises, but this increase is limited to a few degrees on account of the large mass of cast-iron (40 tons) which forms, so to speak, a heat fly-wheel. When, on the other hand, the winding-engine is stopped, the water condensed in the basins is given off again in the state of steam, owing to the heat which has been stored in the cast-iron during the preceding period. The turbine is thus fed continuously by a flow of steam subject to small variations of pressure, presuming that the periods of stoppage of the winding-engine are not too prolonged, and, of course, easily brought to an almost uniform pressure, by means of the regulating valve and governor.

The turbine consists of several wheels, in series, mounted upon the same shaft, their diameter being 35·43 inches (0·9 metre). It receives steam from the regenerator at a pressure very slightly below that of the atmosphere, so as not to interfere with the escape of steam from the winding-engine. From the turbine, steam enters the condenser, in which a vacuum of from 24½ to 25½ inches (62 to 65 centimetres) of mercury is maintained. Under these conditions, the turbine, making 1,600 revolutions per minute, will develop a force of 300 horse-power. This force is utilized to work a double dynamo keyed to the same shaft, the current from which goes to the main switch-board, to be distributed on a three-wire system.

Whenever the winding-engine stops for a somewhat too lengthy period, precautions must be taken that the turbine, which supplies the electric current, should not stop. This possibility

has been prevented by fitting the turbine with an arrangement which automatically passes live steam directly from the boilers. This is so regulated that, for example, if the turbine works at a pressure of 0·90 atmosphere absolute, steam will be admitted until the pressure attains to 0·95 atmosphere by means of a special reducing-valve.

The Bruay turbine has been submitted to exact tests in the shops of Messrs. Sautter-Harlé & Cie. (where the machine was built), running at 1,600 revolutions with a vacuum in the condenser of 24½ to 25½ inches (62 to 65 centimetres) of mercury, and a pressure of 13 pounds per square inch (0·9 kilogramme per square centimetre) at a consumption of 40 pounds (18 kilogrammes) of steam per hour and per electric horse-power at the terminals of the dynamo. If the winding-engine takes 100 pounds (45 kilogrammes) of steam per effective horsepower-hour (calculated upon the coals raised), the turbine will produce, in the form of electric current, 2½ horsepower per effective horsepower utilized, or, say, 250 horsepower, if the useful effect of the winding-engine be 100 horsepower. With a pressure of 1 atmosphere, and a vacuum of 26½ inches (67 centimetres) of mercury, the consumption of steam in the turbine will fall to 30 pounds (13½ kilogrammes) per horsepower-hour. With live steam at 114 pounds per square inch (8 kilogrammes per square centimetre) utilized direct, the steam-consumption would be less than 18 pounds (8 kilogrammes).

The advantage of a series-turbine is to utilize the whole of the fall of pressure down to the pressure of the condenser itself. A turbine, such as that of Bruay, gives an efficiency, which is almost double that of the third cylinder of a triple-expansion engine.

DISCUSSION OF MR. G. R. THOMPSON'S PAPER ON "THE CONNECTION OF UNDERGROUND AND SURFACE-SURVEYS."*

Mr. S. J. Pollitzer (Sydney, New South Wales) wrote that, in his experience, there was no case in which the magnetic-needle method should, for even the shortest connection, be employed, as the variation of the needle at each plat was different and occasionally by many degrees, and none of the plat-variations can be

* *Trans. Inst. M.E.*, 1901, vol. xxii., page 519.

made to agree with the one taken on the surface. In describi the transit-method, Mr. Thompson omitted to give some explan tions which were required in order to make the operation co plete, although he correctly transferred an azimuthal line fro the bottom to the surface: however, the bottom-line had i initial point with its co-ordinates as yet, whereas the one on th surface had it in the vertical axis of the instrument. If he ha said that he marked a third point at the bottom, with the telesco truly vertical, the operation as regards horizontal projectio would have been complete: and to be quite complete, he mig have stated how he ascertained the depth of his bottom-line bel the surface. With regard to his minute calculations on t plumb-line method, Mr. Thompson was correct as to the calcu tions: they were, however, not always necessary in practice. the disturbing elements could be removed, as he (Mr. Pollitz showed in his paper.*

Mr. G. R. Thompson (Leeds) wrote that it is interesting to ha Mr. Pollitzer's statement regarding his experience with the ma netic needle, and his emphatic testimony to its erratic behavi underground, which shows that great care should be taken to perfectly sure of the absence of local attraction before trustin magnetic survey. When, however, local attraction is known be absent, and the underground sights are very short, a magne survey may be the best that is available with any reasona amount of labour. In the introduction to his (Mr. Thompso paper† he pointed out the necessity of determining a common ordinate point and the depth, as well as the common meridian, the paper itself was restricted to the consideration of the degre accuracy attainable in determining the latter. The details conducting the different operations are admirably described Mr. Brough's work on *Mine-surveying*, while a recent paper Mr. E. H. Liveing‡ gives every detail in the practice of the tra sit-instrument method for a deep shaft. He, therefore, gave little detail of the different processes as possible. Regarding th plumb-line method, he would hardly look upon his calculations minute: as they are only such as to determine the equilibrium point of a swinging pendulum, and consist in simply taking th

* *Trans. Inst. M.E.*, 1902, vol. xxv., page 17.

† *Ibid.*, 1901, vol. xxii., page 519.

‡ *Ibid.*, 1899, vol. xviii., page 65.

average reading. By putting on differently-weighted plummets, he altered the conditions of the experiment and determined whether there was any disturbance or not. Should not this proof always be given before its absence is assumed? He looked forward with interest to the publication of Mr. Pollitzer's paper, to see in what manner he removes the disturbing elements. At the Tamarack mine, recently, it was found that two plumb-lines were about 1 inch farther apart at the bottom than at the top, the depth of the shaft being 4,250 feet. After various experiments, it was concluded that the disturbance was due to air-currents and the shaft-top and all openings were closed, when the lines were nearer together, how much nearer the brief note to which he had access did not state; neither could he judge how much the total disturbance of either of the plumb-lines varied from the true vertical. Mr. Hoskold doubts the reliability of plumb-lines for deep shafts; but is it not in such that well conducted plumb-line methods may be expected to compete with telescopic ones? In the case of a dry rectangular shaft, where a possible plumbed base-line may be from 20 to 24 feet long, while the transit base-line could only be 6 to 7 feet long in the same shaft, and where ventilation can be cut off for the time being, he thought that accurate plumbing could be done and results obtained, which for a deep shaft could only be exceeded in accuracy by a very powerful transit-instrument. The accuracy of the result, moreover, would not be left to chance, but freedom from disturbance would be proved; the method is, however, tedious. The power of the telescope must increase for deeper and deeper shafts when the transit-method is adopted. Mr. Hoskold even admits that the telescope on his 5 inches theodolite is not sufficiently powerful for deep shafts, while claiming for his 6 inches instrument that it is. It would be interesting to know in this connection the power of telescope that the makers place on the respective instruments. He intended the error which he fixed for pointing the telescope to be the outside limit, and was prepared to have it reduced somewhat in the discussion; but he was hardly prepared to concede that in practice it would be more imaginary than real. The fact of a very accurate holing having been made at the Severn tunnel does not in any way prove this, for the conditions were those in which great magnification was not required. A shallow tunnel-shaft is by no means the same as a deep mine-shaft.

Mr. VICTOR WATTEYNE (Brussels) wrote that the compass is most generally used in Belgium for underground surveys. In addition to the convenience of its use, the instrument has the valuable advantage of not continuing the angular errors which may have been committed. In fact, the compass indicates, each time, a direction independent of those which have been observed previously; an error, committed in a previous sight, cannot, therefore, influence this direction; and has no other consequence than to displace the starting-point of the latter. The trace of the survey would certainly be somewhat different from what it ought to be, but it would remain parallel to the true trace, and would only depart from it by a quantity proportional to the length of the sight in which an error had been made. It is different with the thodolite, where an error of angular measurement made at the start is carried throughout the entire traverse, and if this is very long, an error of 1 minute, for example, may have the consequence of causing considerable error in the final point from its true position. At the surface, this objection is generally less, for one has usually several points, which can be sighted from different stations, and one can thus verify whether any of the sights have been taken wrongly. In a mine, on the other hand, these methods of verifications are very rare, or in the largest number of cases do not exist at all. This superiority of the compass is well known, and if he (Mr. Watteyne) mentioned it here, it was because it seemed sometimes lost sight of or not appreciated at its full value, in discussions on the comparative advantages of the compass and the theodolite. It would seem, therefore, that preference should be given to the use of the compass in underground surveys; and this would be the case if one could be certain that the direction given by the compass at the bottom of the shaft is really the true direction. Unfortunately, this is far from being the case, and the causes of error are numerous. One can avoid the consequences of variations of the magnetic needle, by taking at the surface identical compass-observations upon a fixed direction, which is well known, at the same time as the underground survey is being made, and by carefully noting the declination during the whole time that the survey lasts. But a cause of error that cannot be avoided is that which results from the fact that at the same moment the declination might be different in the mine and at the surface, that is to say, that the azimuth indicated by the compass would not be the same if one sighted at the same moment in the mine and at the surface. It is probable that

these differences of declination between the top and bottom exist, and also that these differences vary with the depth.

In a recent paper, written jointly with his colleague, Mr. Libert, it is stated that in examining the plans of different collieries which work regular seams, it has been noticed that the same drifts, traced according to surveys made with the compass at different depths, assume on the plans positions making a certain angle with each other, and that this angular divergence is always in the same direction (Figs. 1 and 2, Plate XIV.).* Let P be a shaft, and A B C a coal-seam worked successively at depths of 900, 1,200 and 1,500 feet, the levels of one winning becoming, subsequently, the return-airways of the winning immediately below it. Plans have been made by means of the compass of the levels of each winning. The plan of the level of the 900 feet winning as surveyed by the compass is A A ; and at 1,200 feet, the compass gives B B as the direction of the level. If the working-face, T, is afterwards surveyed as far as the return-airway, which, as above said, is the old level, A A, it will be found that this airway does not pass through A A, but through A′A′. The same deviation happens at the 1,500 feet winning, where the return-airway is found to occupy the position B′B′ instead of the position B B. As A′A′ is identical with A A, and B′B′ is the same place as B B, some error has manifestly been committed. What is the cause of it? There might evidently have been some negligence in survey, but if there were no other causes it would be very extraordinary that these negligences should always produce deviations in the same direction. It must also be remarked that the plan of the cross-measures drifts has undergone deviations of the same kind, and that the three roads, P A, P B and P C, supposed to be in the same identical direction, have taken, in the plan, positions which are not vertical, one above the other, as indicated in Fig. 2 (Plate XIV.). The explanation of these errors, which are produced even when working with the greatest care, is easily found if one admits that the declination of the needle is different at 1,500 feet from what it is at depths of 900 feet or 1,200 feet. This difference will necessarily result in the lines C C, B B and A A, which are in reality parallel (as would result from the hypothesis of a perfectly regular deposit), being indicated by a compass-survey in different directions. The variations of declination with depth should not be a matter of surprise,

* *Annales des Mines de Belgique*, 1902, vol. vi., page 896 ; and vol. vii. page 99.

as it is indeed well known that isogonal lines, that is to say, lines along which the magnetic declination is the same, are not meridian lines, nor are they straight lines or regular curves, but on the contrary sinuous lines, at times very irregular. It is not surprising that such lines should not be projected into the interior of the earth in absolutely vertical surfaces. The contrary seems more probable, and it may thus be that in advancing vertically into the earth one passes from one isogonal surface to another, and that consequently there should be a different magnetic declination. If, indeed, one considers that isogonal lines or rather surfaces are shifting at each instant, and that their sinuosities are different, from one point to another, it may be concluded that the law of the variation is different for each locality, and that it may undergo modifications from one instant to another. It follows from what has been said that a knowledge of the methods and of the instruments to be employed in order to establish without the help of the compass a connection between the mine and the surface is of the highest importance. He (Mr. Watteyne) might add that in a mine where it is of importance to have exact plans, it is indispensable to determine at each level, by methods independent of magnetic perturbations, that is to say, without the aid of the compass, a direction, referred to a well-known direction on the surface, which would serve as a base-line for all plans, made at that level, whether such plans were made by the compass, by means of the theodolite, or by any other instrument.

DISCUSSION OF MR. H. D. HOSKOLD'S PAPER ON "A NEW CIVIL AND MINING ENGINEERS' TRANSIT-THEODOLITE, ETC."*

Mr. S. J. Pollitzer (Sydney, New South Wales) wrote that Mr. Hoskold's new transit-instrument was certainly a most excellent idea, very carefully designed, and he deserved great credit for it. Mr. Hoskold provided his eye-piece with a diaphragm for the purpose of measuring distances, and this was the very best thing that he could have done; he adjusted his instrument on the top of a traversing-stand with various adjusting screws, until his vertical spider-line would exactly bisect the two lighted points on the strained copper-wire at the bottom of the shaft. Here was the same identical omission as that made in Mr. Thompson's

* *Trans. Inst. M.E.*, 1901, vol. xxii., page 536.

To illustrate Mr. V. Watteyne's "Notes on Compass-surveys."

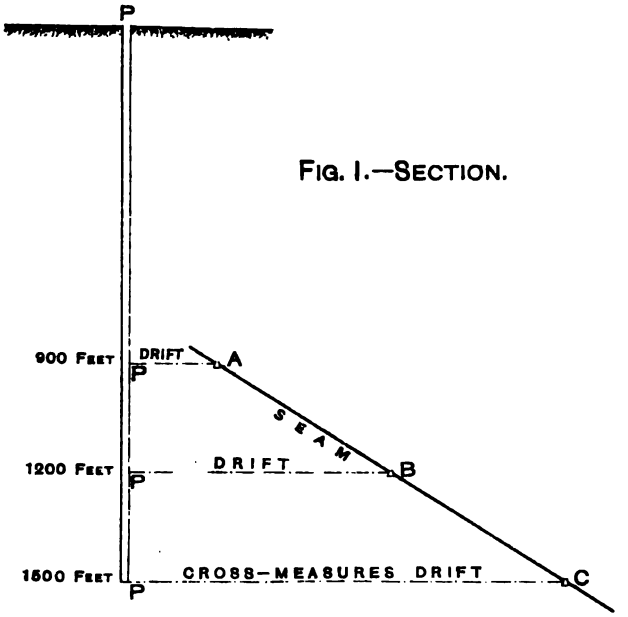
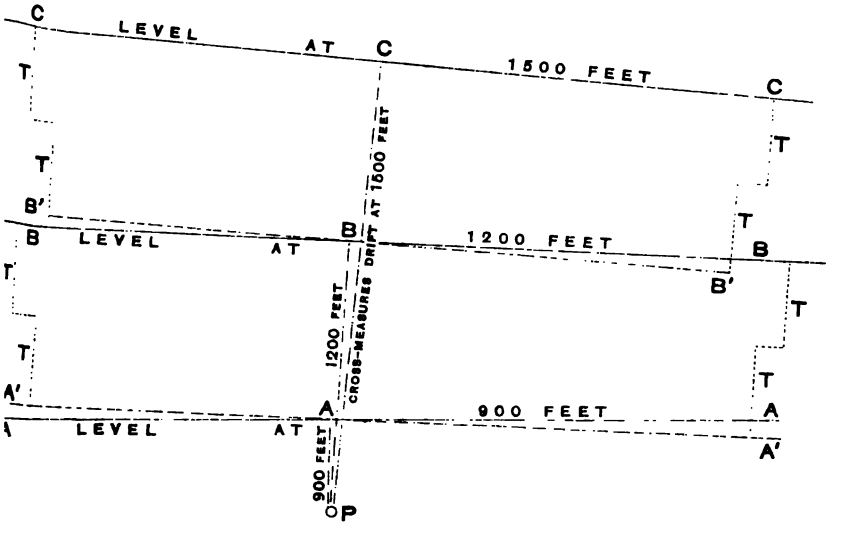


FIG. 1.—SECTION.

FIG. 2.—PLAN.



paper, with the difference that it was more serious in the instrument, because it was provided with a diaphragm which was not used: moreover, as explained by Mr. Hoskold, it could not be used. To make appropriate use of the diaphragm, the operation ought to be augmented by shifting, afterwards, the two lights, along the stretched copper-wire forward or backward until each was also bisected by the horizontal lines of the diaphragm. Could Mr. Hoskold say, supposing a depth of 3,000 feet was observed, that the two horizontal lines of the diaphragm would bisect two points within the narrow limits of the shaft? or, were there different diaphragms attached to the instrument for observing at different depths? The rack-and-pinion movement of the telescope to obviate the use of high Y standards, on account of vibration, was rather too delicate to avoid eccentricity of the telescope, since the possible vibration of a couple of inches of the higher Y was more imaginary than real. Another important matter, which Mr. Hoskold did not explain, was:—When using the theodolite for ordinary surveying, how was the instrument centred over a point, with a cylindrical hole, 1 inch in diameter, in its centre? Doubtless he had something to fill it, provided with a hook for the plumb-bob.

There is an inherent defect in the principle of the construction of theodolites in general, which ought to be remedied. That is, when an instrument had been carefully centred and levelled, the surveyor thought that the vertical axis of the instrument was the mathematical prolongation of the plumb-line. This, however, was not always the case, especially when working in hilly country, where the parallelism of the two parallel plates could not always be maintained; the upper plate naturally was always horizontal, but not the lower; and it often happened that the two plates were $\frac{1}{8}$ inch more apart on one side than on the diametrically opposite side, and the hook for the plumb-bob was fixed to the lower plate, which was not level, throwing it out thereby from the vertical axis of the instrument by an eccentricity, $X = y \sin \alpha$; consequently, the two plates should be as much as possible parallel and in an horizontal position, and the distance between the hook-eye and the centre of the ball-and-socket motion should be as little as possible. But with the existing system of instruments, the latter could not be much reduced, so there is room for improvement in the mode of fixing the hook.

In his opinion, however, Mr. Hoskold's new instrument was

really a most superior invention for the purpose of surveying vertical shafts; but in shafts on the underlay it would be out of place, without additional improvements for that purpose.

Mr. H. D. Hoskold (Buenos Aires) wrote that it was intended that his paper upon his new transit-theodolite should be written as concisely as possible, leaving some minor points to be inferred. It was gratifying, as also interesting, to find that Mr. S. J. Pollitzer (Sydney, New South Wales) had appreciated and kindly expressed a favourable opinion upon the new instrument in question, and the writer desired to thank him for his attention.

In reference to the question as to what depth a short base-line may be observed from the top of a shaft, it may be stated that the hole in the vertical axis of the instrument is sufficiently large to enable an observer to take a vertical angle through it up to 3 degrees, or 1 degree 30 minutes each way from the perpendicular line. If, therefore, two illuminated marks were placed, 12 feet apart, at the bottom of a shaft, they could be bisected with the vertical spider-line in the focus of the telescope, under the above-named angle, at a depth of 229 feet; and, for the same length of base-line, under a diminishing vertical angle, to any depth within the power of the telescope. If the base-line between the two illuminated marks were to be diminished to suit the narrow conditions of a shaft to, say, 9 feet, then the minimum distance or depth would be diminished to about 171 feet; and to be continued in depth, according to the principle cited in the former case. For a depth of 3,000 feet and similar length of base-line, the angle subtended between the illuminated marks would be very small, still the bisection would be as perfect as at lesser depths, with a probable difference that it may be convenient to increase the illuminating power with the depth. There is no more difference or difficulty in sighting two points at the bottom of a shaft a given distance apart, than there would be in sighting to two points placed an equal distance apart on an upright illuminated pole at night upon the surface, without the necessity of requiring the aid of different diaphragms.

The socket, or sleeve, forming part of the horizontal axis, is, as already noted in his paper, made sufficiently long to provide for a smooth undeviating longitudinal motion when the middle part of the telescope slides in it. This part of the telescope-tube, as also the whole, is turned as mathematically correct, in

reference to its optical axis, as mechanical art could make it, consequently there is no more "eccentricity" in it, than there is in the vertical axis upon which so much art is expended to render it as free from eccentricity as is possible. In very large surveying instruments this is rigidly tested by the readings of three equidistant verniers. It must further be observed that the telescope does not revolve vertically in the socket or about its optical axis, but is only moved forward or backward by its rack-and-pinion screw. The proof of accuracy in this motion is to focus the telescope upon a fine distant object, giving motion to the telescope in its sleeve, and observing whether the vertical spider-line continues in contact with the distant object. After various rigid trials, it was found that no deviation whatever existed.

To aid in placing the instrument over a fine station-point, the usual hook for suspending the plumb-line is screwed into a metal plug, which also, in its turn, is screwed into the bottom of the hole of the axis.

The instrument is not mounted upon parallel plates, but upon a triangular levelling base-frame carrying three levelling-screws which are locked into another triangular frame which is screwed upon the tripod-head. Upon this latter levelling-frame, a low traversing-plate with a circular clamp is mounted, forming the central part of it, by the aid of which the theodolite, with the hook and suspended plumb-line, is made to traverse a given distance from the centre, so that every facility is afforded for centring over a fine station-mark.

The common tripod-stand employed in all surveys, except when sighting down a shaft, is what is termed an open one, with a large hole cut in the table-plate of the head, and inside the upward projecting male-screw to which the triangular levelling-frame is screwed. Consequently, when the instrument is centred over a station, the fine point of the suspended metal-bob, the plumb-line, and the centre of the vertical axis of the instrument, are all in the same vertical plane. The common defects inherent in ordinary constructed instruments referred to by Mr. Pollitzer are, therefore, eliminated altogether.

In levelling ordinary surveying-instruments with parallel plates and four conjugate screws, a strain is put upon the vertical axis, and this strain is augmented when there are high and heavy Ys, a proportionate long telescope, vertical circle and other appendages, all of which render such an instrument too top-

heavy and awkward, and certainly liable to vibration in windy and mountainous regions. The tendency of each pair of levelling-screws, between the parallel plates, is to produce opposing and straining forces with a corresponding expansion of the weaker parts of the metal forming the small diameter of the screws, with a resulting proportionate derangement of the spirit-bubbles after the instrument has been levelled; besides, as Mr. Pollitzer observes, other defects appear when working in "hilly country." Any retouching of the screws, for fine levelling, must be done with the two hands, for the screws frequently are jammed, and difficult to move when the levelling-plates are displaced from their parallelism; but considering that when a triangular levelling-frame and three screws are used, such difficulties cannot exist, because each screw is independent of the other, and after the first levelling, if any small displacement of the spirit-bubbles occurs, it can be readjusted by turning one of the screws. For constant hilly work, a tripod with sliding legs would be most convenient, one of which may be shortened to suit the inclination of the mountain-side and so facilitate the setting up and levelling.

Additional facility is provided for centring the writer's instrument over fine station-points, and this is effected by placing the telescope to look towards the nadir, setting it up level over the station, and then, by the centring apparatus, bringing the cross of the spider-lines to bisect the fine point in the station; but, for this object, a suitable additional eye-piece must be provided, etc.

Mr. Pollitzer thinks that the instrument under discussion could not be applied "in shafts on the underlay," because the lowness of the Ys does not permit of observing large depressed angles; but this apparent difficulty is overcome by slipping over the objective end of the telescope a properly prepared metallic tube, similar to but longer than an ordinary sunshade, the outer end of which is closed, with an opening cut in the under-side large enough to admit rays of light, which would strike against a large reflector or glass-prism placed in the tube opposite to the opening and at an angle of 45 degrees. If, therefore, an electric lamp or some other illuminated point were to be placed at the bottom of the underground incline, or under-lay shaft, and the telescope brought into that direction, and sufficiently elevated for the reflector to receive the rays of light from the lamp, these would be reflected to the focus of the telescope, and bisected by

the vertical spider-line, and the operation would be effected as efficiently as it would be if observed directly through the telescope. This reflecting apparatus or attachment is termed the "complimentary-angle measurer." Any surface-line may be connected in this manner to the line passing through the underlay shaft, under any depressed angle down to the perpendicular. When observing an illuminated point as above described, the angle of depression is easily determined by employing the reading on the vertical circle, as one of the elements: that is, the angle thus obtained is measured from the perpendicular line, consequently it becomes the complement of the angle required, or that formed between the horizontal and the underlay shaft-line. Evidently Mr. Pollitzer is labouring under the impression that he (Mr. Hoskold) intended his new transit-theodolite, under notice, to be used in narrow, low, zig-zag inclined roads in mines; but considering that the largest form of the instrument is constructed with 6 inches divided circles, a long and powerful telescope, it is more particularly adapted for extensive land-surveying operations, as also in large mine-headings, railway and other tunnels, and in making a connection between underground and surface surveys. However, the smaller sizes, with 4½ and 5 inches circles, mounted upon low tripod-stands, are well-suited for general underground-surveys, and may be so employed with the greatest facility and efficiency. In all such cases, the greatest speed and accuracy would be obtained by the use of three interchangeable tripod-stands, with suitable lamps.

The small apparatus attached to the eye-piece for measuring distances consists of a micrometer with divided circle, and not a simple diaphragm with stadia spider-lines fixed upon it as Mr. Pollitzer thinks. This micrometer can be made to read very fine angles down to either 1 or 2 seconds of arc, consequently distances can be determined with great facility and accuracy by the rule already given in the writer's paper published in the *Transactions*.*

He (Mr. Hoskold) had already explained that he had designed a special traversing-stand,† upon which the new instrument is mounted when a perpendicular sight is taken down a shaft. This stand has been completed, and it is proposed soon to give, in the *Transactions*, a short notice of its use.

* *Trans. Inst. M.E.*, 1899, vol. xix., page 208. † *Ibid.*, 1901, vol. xxii., page 550.

DISCUSSION OF MR. DUNBAR D. SCOTT'S PAPER ON "MINE-SURVEYING INSTRUMENTS."*

Mr. Ludwig Tesdorpf (Stuttgart, Germany) wrote that he had read, with great interest, Mr. Dunbar D. Scott's paper on surveying instruments. In the description of the orientation-instrument,† it had been assumed that in every measurement the additional objective lens must be employed.‡ This would certainly be awkward and take time, and might lead to a derangement of the line of collimation. He therefore appended an exact description of the mode of use of the instrument. The orientation instrument, shown in Fig. 1, is specially distinguished from other types of instruments with a declination-needle, by the fact that the coincidence of the north-south lines with the axis of collimation can be directly tested from time to time by means of the telescope, and this constitutes its special feature. The case of the compass-needle rests upon a support that can be adjusted in all directions, and the former can be readily removed in order to clean the magnetic needle. By a suitable device, it is secured in an exactly true concentric and diametral position after being replaced. The magnetic needle is also arranged for reversing. According to the size of the instrument, the needle has a

Fig. 1.—Orientation Instrument.

* *Trans. Inst. M.E.*, 1902, vol. xxiii., page 575.

† *Ibid.*, 1902, vol. xxiii., page 598.

‡ This is, however, by no means necessary.

length of 6 to 8 inches (15 to 20 centimetres), the diameter of the limb of the horizontal circle being always equal to the length of the compass-needle. This needle is beam-shaped, and at both ends fine lines are engraved on it (Fig. 2) by means of a diamond. The cap consists of a highly-polished garnet or ruby. The removable front lens is only employed for the adjustment of the compass-needle; and during other observations it is not used, but remains in the box.

After the instrument has been adjusted, measurements are made as follows:—The zero of the vernier is first set to the zero of the horizontal limb; then the body-piece of the instrument is turned until the magnetic needle swings freely; by means of a hand-lens the needle is then set in the magnetic meridian by causing the fine line, *a*, of the magnetic needle to coincide exactly with an equally fine line, *b*, engraved on the side of the compass-box (Fig. 2). The line, *b*, is brought into coincidence with the axis of collimation, when the instrument is being adjusted by means of screws, *c* and *d*.*

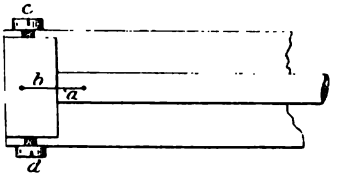


Fig. 2.

Measurements are performed with this instrument with great rapidity and accuracy. It is only necessary to bring the lines *a* and *b* (Fig. 2) into coincidence in order to be sure that the line of collimation of the telescope shall lie exactly in the magnetic meridian. Instruments of this type are made as may be desired with or without vertical circles. Fig. 1 shows the instrument with a vertical circle, this latter having covered divisions. The second removable and easily adjustable eccentric telescope is employed especially for zenith- and nadir-observations. For illumination at night, a lamp is placed at one side, which throws light, through the perforated trunnion of the telescope, upon a very small mirror, 0·08 inch (2 millimetres) in diameter, and thence it is reflected into the field of view, so that even by night the cross-wires of the eye-piece appear dark black on a bright ground.

* As with other instruments, all the angles are reduced to magnetic north or zero, but it can be effected much more exactly with this than with other types of instruments.

Prof. H. Louis (Newcastle-upon-Tyne) ventured to think that Mr. Scott had failed to do justice to the real merits of the three-tripod system of surveying, which is largely practised in this country and especially in coal-mine surveys. Three tripods exactly similar are used, the middle one carrying always the dial or theodolite, while the first and last carry signals (which in fiery collieries are of course safety-lamps). When the back-sight has been taken, the last tripod is moved forward by an assistant and levelled approximately, and the instrument is then removed to the tripod, which is now in the middle, the lamp (or what was the fore-sight in the previous sight) being brought back to give the next back-sight, and so on. By this mode of working the rate of surveying is quite doubled, which is a very important consideration in a busy pit working at high pressure, and the work is at least as accurate and probably more accurate than it is when only one tripod is used. He (Prof. Louis) did not quite understand whether Mr. Scott's sentence, "the essential advantage of the system leaves no permanent points for future reference,"* was intended to be laudatory or condemnatory of the three-tripod system; in his (Prof. Louis's) opinion it was one of the decided advantages of this method that it enabled stations to be sighted with the utmost accuracy without requiring permanent marks to be put in at each station, as he was opposed to the multiplication of such permanent marks, which only led to confusion, unless they were restricted to points where they would be required subsequently for the starting or closing-points of branch-traverses. If a check-traverse has to be made at any future time along the same roadways, it is rather an advantage that the second traverse will employ intermediate stations different from the first one.

With regard to Mr. Scott's remark that the rack-and-pinion was in use for both limbs of a theodolite down to the end of the eighteenth century,† it might be interesting to record that the first theodolite owned by Prof. Louis was a London-made plain theodolite, made, apparently, subsequent to 1850, in which both the horizontal limb and the vertical semicircle were worked by rack-and-pinion, although the bodypiece was fitted with the usual clamp and tangent-screw.

* *Trans. Inst. M.E.*, 1902, vol. xxiii., page 590.

† *Ibid.*, page 595.

He (Prof. Louis) quite endorsed Mr. Scott's condemnation of magnetic-needle surveying as only "applicable to the most ordinary kinds of work,"* and utterly failed to see what advantage could be hoped for from such an elaborate instrument as the Tesdorpf-Breithaupt orientation instrument. What was the use of reading the position of a magnetic needle to 20 seconds, when its diurnal variation might exceed 8 minutes? This was surely an affectation of accuracy that could serve no practical purpose. It ought to be clearly understood that the use of the magnetic needle should be restricted to filling in details of surveys, and to any other survey-work in which errors up to a quarter of a degree might be disregarded. Even for such work, it is probable that the plane-table deserves preference over the miner's dial, as the former instrument is quite as rapid and quite as accurate as the latter, and avoids the risk of serious error due to some unknown disturbing magnetic influence.

He (Prof. Louis) would be glad to know what advantage, if any, Mr. Scott considered the Brunton hand-compass to possess over the prismatic compass: there are several types of combined prismatic compass and clinometer that appear to do everything that the Brunton compass does, at least as well as that instrument. He (Prof. Louis) had tried to use the Brunton compass, but found that its range in taking bearings in hilly districts appeared to be so limited, that he had given it up.

Finally, he (Prof. Louis) was sorry to see that Mr. Scott used the word "tachymeter" instead of "tacheometer"; he ventured to think that the latter form had the sanction of priority as well as perhaps being the more correct etymologically.

Mr. H. D. Hoskold (Buenos Aires) wrote that as he had already written three papers upon a similar subject, provoked by Mr. Scott's paper on "The Evolution of Mine-surveying Instruments," those of others, and resulting discussions,† he thought that the subject-matter had been so far treated as to leave but little or no room or necessity for going over the ground again, and introducing the same subject in a new form in other places.

* *Trans. Inst. M.E.*, 1902, vol. xxiii., page 598.

† *Transactions of the American Institute of Mining Engineers*, 1898, vol. xxviii., page 679; 1899, vol. xxix., page 931; 1900, vol. xxx., pages 783 and 803; and 1901, vol. xxxi., pages 25, 56, 716, 884 and 921.

It was, however, evident that Mr. Scott considered the matter from another stand-point, and he was to be highly commended for his researches into the dusty records of the past, and in bringing forward in his American and British papers the results of his labours. His American paper received a considerable amount of attention from various professional veterans, whose independent papers and discussions exhibited their appreciation of the great value and importance of mine-surveying. It was, therefore, to be hoped that his British paper, which was now under discussion, would receive equal attention from British mining-engineers, and, in that sense, he (Mr. Hoskold) was pleased to make an initiatory movement.

In taking a retrospective view of the labour of some few of the old English pioneers in science and inventions, upon whose achievements in the advancement of the sciences, engineering and surveying arts, the world had so much to depend, he (Mr. Hoskold) desired it to be understood that he was far from being prejudiced, and had no desire or object to detract from the merits of foreigners; but, at the same time, he believed that it would not be out of place to show in a legitimate manner that the British nation had been foremost in introducing refined inventions and improvements in surveying-instruments and in devising means for more exact work and progress in the art of surveying. And, although this might appear somewhat anomalous, still, in order to do it in an effective manner and make a fair comparison, it had been necessary to refer to both ancient records and more recent documents.

The tablets, or tile-library, discovered by Layard and others, and now deposited in the British Museum, London, afford abundant evidence, of a positive nature, that the "estates near to the rivers and canals, and round about the cities of southern Babylon, were systematically surveyed some 2,400 years B.C." Consequently, it is to be inferred that divided circular astrolabes were not only used in astronomical observations, but must have been applied to land-surveying, and, probably, also, to mine-surveying, and that, at intervals, during a long period of time, the art was forgotten, neglected, or hidden, and revived from time to time, until it made its appearance in Europe.

It is not, therefore, surprising to find that the planisphere,

1550 (Fig. 10),* the Digges theodolitus, 1571,† the Dutch circle with six plain sights, 1620-1625,‡ the French wooden circle, 1692,§ and others which he could mention, are all of the same type-class.

No doubt the Digges theodolitus led to the construction of his topographical instrument with vertical semi-circle and plain sights,‖ and it was doubtless the original type from which others were afterwards constructed with improvements, and represented in Britain to-day by the plain or cradle-theodolite. It would be difficult to define the date of each successive improvement, and, consequently, there is a gap in the record from the time of Thomas Digges, 1571, to that of the grand old firm of the Sissons, whose curious theodolite, with telescope, was introduced sometime prior to 1723. However, he (Mr. Hoskold) believed that the intermediate period, referred to above, was represented by the instrument illustrated by Fig. 1, an example of which is still preserved in the Conservatoire National des Arts et Métiers in Paris, and is reported by the authorities of that establishment to be of English

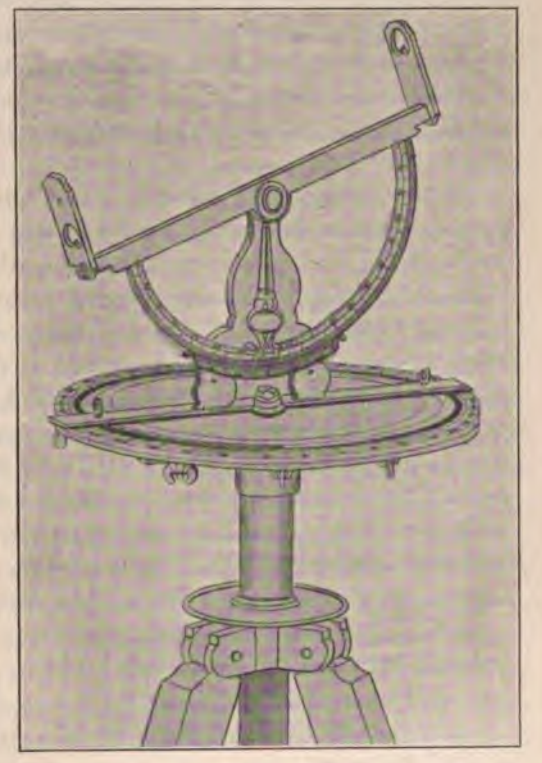


Fig. 1.—English Theodolite, 1632 to 1635.

* *Trans. Inst. M.E.*, 1902, vol. xxiii., page 584.

† *Ibid.*, 1900, vol. xix., page 182.

‡ *Recherches sur les Instruments*, etc., by Col. A. Laussédat, Paris, page 67.

§ *Ibid.*, page 84.

‖ *Trans. Inst. M.E.*, 1902, vol. xxiii., page 591.

construction. A vernier is attached to the semi-circle of that instrument, and it has plain sights; but the name of the maker is not known. The vernier, however, affords evidence that it could not have been constructed before 1631; but it is probable that an approximate date for the construction of this instrument would be about 1632-1635. The original theodolite of Sisson had been illustrated and described in his (Mr. Hoskold's) third American paper,* and the description was now repeated by Mr. Scott.† This instrument was introduced some time prior to 1723. Afterwards, Sisson greatly improved it, and in the hands of successive makers it assumed the form now known as the English cradle-theodolite. Other instruments of a superior type will be referred to in this discussion.

When referring to telescopes and telescopic sights, that is, placing lines in the focus, Mr. B. S. Lyman, of Philadelphia, in his well-digested paper, or discussion of Mr. Scott's paper on "The Evolution of Mine-surveying Instruments,‡ stated that "young Gascoigne . . . . was the leader, and, already by 1640, he used for the purpose a hair or thread at the focus. It was even claimed in 1675 that he [Gascoigne] had been the first to use a telescope of two convex lenses. At any rate, he was evidently the first to use telescopic-sights."§ He (Mr. Hoskold) also proved in his second American paper,‖ and in his reply to the discussion upon his "Notes upon Ancient and Modern Surveying, and Surveying-instruments," etc., that Gascoigne was the first to invent and apply an instrument for finding distances probably before, or at least, "between 1638 and 1643;"¶ and referring to the same subject, Mr. Lyman stated that "twenty years later it was reinvented upon the Continent."**

Whether the original form of telescope was discovered first, as had frequently been alleged, by Roger Bacon, 1290; Porta, 1561; Digges prior to 1570; the Dutch in 1608; or Galileo in

* *Transactions of the American Institute of Mining Engineers*, 1901, vol. xxxi., page 716.

† *Trans. Inst. M.E.*, 1902, vol. xxiii., page 593.

‡ *Transactions of the American Institute of Mining Engineers*, 1898, vol. xxviii., page 679.

§ *Ibid.*, 1900, vol. xxxi., page 79. ‖ *Ibid.*, 1900, vol. xxxi., page 25.

¶ *Trans. Inst. M.E.*, 1901, vol. xxi., page 411.

** *Transactions of the American Institute of Mining Engineers*, 1900, vol. xxxi., page 78.

1609, was not material to the points to be deduced from this discussion, for the reason that Hall, an Englishman, in 1733, and Dolland, prior to or about 1758, were the persons who originally invented, constructed and practically applied achromatic lenses to the telescope, and thus perfected and brought it to a more fit condition to be attached to angular measuring-instruments.

Without doubt, the climax in invention, at that period, calculated to perfect geodetic and other surveying instruments, was arrived at by the celebrated Ramsden, when he completed his first circular dividing-engine about 1773 or 1774, without the use of which the other prior inventions in telescopes would have left astronomical and surveying instruments in the same condition in which they were, as regards the method of dividing the circle, before Ramsden's invention. Ramsden constructed at least four dividing-engines, one of which was received at the Conservatoire des Arts et Métiers, Paris, in 1795. A second is preserved in the South Kensington Museum, London, and two others of Ramsden's make are still in excellent condition, and constantly used to divide circles by Mr. Parsons, a London divider to the trade. One of the last is reported to be "one of the finest pieces of mechanism that the world ever saw." The circle of the great 36 inches geodetic theodolite of Ramsden, 1780 to 1783, illustrated in Fig. 5 of his (Mr. Hoskold's) paper,* was divided by his engine, and so perfectly was the work done that the probable error of a single observation of a fine object with this instrument would not amount to 0·2 second of arc. Ramsden was the first to illuminate the cross-hairs in the telescope of his transit-instrument by perforating the axis. He was also the first mathematical artist to apply micrometrical readings to the divided circle of his great theodolite; and Quekett† ascribes to Ramsden the practical introduction of spider-lines in micrometers; but, according to the opinion of some persons, Troughton first placed such lines in the focus of telescopes. Fontana, 1755, and Rittenhouse, probably about 1785, have also been mentioned in connection with this invention. Among many claimants, with interested parties to back them up, it was difficult to determine who was the first to devise and introduce certain inventions.

This remark applies to the microscope, and it is stated on no-

* *Trans. Inst. M.E.*, 1900, vol. xix., page 188.

† *Encyclopedia Britannica*, 1883, vol. xvi., page 243.

less an authority than Mr. Lyman that "Huygens' investigations made it probable that it [the compound microscope] was first invented by Drebel, a Dutchman, in London, about 1620."*

Since Ramsden published an account of his dividing-engine in 1777, foreign makers have also constructed dividing-engines upon the same principles. The one in the Conservatoire des Arts et Métiers, Paris, would, doubtless, have afforded the details for the construction of others. Previous to 1843, the late Mr. William Simms, of the firm of Messrs. Troughton & Simms, constructed a dividing-engine, and Mr. William F. Stanley stated to him (Mr. Hoskold) that it is believed to be the best in London.

The circles of the great 36 inches geodetic theodolite constructed by Messrs. Troughton & Simms for the Indian Trigonometrical Survey, and illustrated by Fig. 6,† were divided by the Simms dividing-engine, and after a rigorous and delicate examination of the divisions of the circles had been made, the late Col. Strange (the late technical examiner of Indian geodetic instruments) could not discover 1 second of arc of difference between the divisions. The original dividing-engine is still in constant use in the establishment of Messrs. Troughton & Simms.

A careful examination of his (Mr. Hoskold's) paper‡ will show that although Snellius, 1615, and Picard, about 1669, commenced surveying, still, it does not appear that the great English pioneering surveyors, Norwood, 1635, and General Roy, 1747 to 1755, derived any instructive principle from them, and if Newton had not discovered his ever-memorable principles, whence he deduced the true figure of the earth, the French would not have been incited to the efforts which they afterwards exhibited. It is scarcely necessary to mention the names of succeeding English surveyors, such as Mudge, Dalby, Colby, Kater, Lambton, Everest, Walker and others, in order to prove that the British nation possessed original thinkers capable of carrying into effect the application of scientific principles upon which depended the good results of the practical work that they all carried out, without deriving anything vital from the scientists of neighbouring nations.

Coming now to the discussion of the great aid that surveyors

* *Transactions of the American Institute of Mining Engineers*, 1901, vol. xxxi., page 74.

† *Trans. Inst. M.E.*, 1900, vol. xix., page 197.

‡ *Ibid.*, 1900, vol. xix., page 184.

of all classes and nations have received in the reduction of their practical operations with the greatest ease, accuracy and facility, we have only to refer to the great mathematical ingenuity displayed by Baron Napier, who, in 1614, published his remarkable invention of logarithms. His book contains a description of the nature of logarithms, and tables of natural sines and their logarithms to every minute of the quadrant and to seven places of decimals. Briggs, the Savillian professor of geometry at Oxford, followed, in 1616, with a table of logarithms. Gunter, the colleague of Briggs, published, in 1620, the first calculation of "Briggian logarithms of trigonometrical functions." This book was called *Canon Triangulorum*, and it contained logarithmic sines and tangents for every minute of the quadrant to seven places of decimals. The great work left by Briggs, afterwards published, in 1638, under the title of *Trigonometria Britannica*, was the climax of his achievements, and contained tables of logarithmic sines to 14 places of decimals, and tangents to 10 places of decimals, as also tables of natural sines, tangents and secants. The productions indicated and initiated by Napier, and continued by Briggs, placed the British nation in an independent position for all time, so far as facile means for calculations were concerned, in the benefit of which foreigners partook in a high degree. Whether Napier derived any notions from the work of Regiomontanus (1436 to 1476) in the same manner as Mr. Scott says that Reinhold had done, is impossible to decide; however, it may have been possible. That additions and improvements in the method of arranging such tables have followed is certain; but the principles laid down by Napier, and continued by Briggs upon a different basis, have not been nor ever will be superseded. The natural sines, etc., referred to above, formed of themselves co-ordinates. The logarithms and logarithmic sines also afforded facile and direct means for the same object, and if the surveyors of that period, and for some time afterwards, did not apply those principles, it was not for the want of means ready at hand.

Mr. Scott observed that Reinhold "explains the co-ordinate system of plotting, and actually introduced a lucid treatment of trigonometrical calculation after Regiomontanus (1436 to 1476)"* but it is not stated that Reinhold prepared tables to

* *Trans. Inst. M.E.*, 1902, vol. xxiii., page 576.

facilitate the use of the co-ordinate system, without which a mere "explanation" would possess less value. It is not probable that the work of Reinhold was known in England, at least to any extent, up to the time when Budge published his last edition in 1866; at any rate, it is not referred to in any work upon surveying, in English, known to him (Mr. Hoskold), neither has he seen any English book upon mine-surveying earlier than Houghton, 1681, and probably such does not exist. Nevertheless, there is no reason for supposing that the plan of surveying indicated by that author may not have existed for two or three centuries earlier. If, however, we take the moderate estimate of 250 years, that would take us back to 1431, leaving a period of, at least, 251 years to invent means of applying the magnetic needle to mine-surveying, or from the time of Necham, 1170 and 1180, who, as he (Mr. Hoskold) had previously stated, if not the first inventor, introducer or user of the magnetic needle, was the first to write about it in England.* If there is nothing certain about the estimate of time that we have made above, we shall, at least, be within the limits of probability.

The Romans worked the tin-mines of Cornwall, the lead-mines of Derbyshire and the iron-mines of Birmingham (at intervals) down to 300 A.D.† According to the State papers, Henry II. granted permission to work iron-mines and to erect forges to reduce the mineral to metal, somewhere between 1154 and 1160, before Necham wrote. There might, therefore, have existed a need for mine-surveying, at any rate, upon a small scale, no matter how rudely conducted; and, as he (Mr. Hoskold) had previously stated, such operations may have been carried on by means of a small plane-table, or three-legged stool, a chalked string or cord, and a measure, until the introduction of the magnetic needle. He (Mr. Hoskold) had not discovered any record proving that the mines of the Hartz were much explored earlier than about 1200. Earlier records may, however, be accessible to others. It is interesting to note that it is believed that the first book published in Germany upon mining appeared in 1504 to 1505, with other editions in 1515 to 1518.

The Director of the Mining Academy, at Freiberg, courteously sent to the writer a photograph of the title-page of the latter edition of the work referred to, as also of two old instruments

* *Trans. Inst. M.E.*, 1900, vol. xix., page 181.

† *Cyclopedia of Classified Dates*, 1900, page 840.

employed in mine-surveying at the period mentioned. A description of these rarities, probably the only examples known, was published in his (Mr. Hoskold's) second and third American papers,* and Dr. Raymond was good enough to translate the title of the book from German into English. It is as follows:—"A well arranged and useful little book: How mines should be sought and found, of all kinds of metal, with the figures suitably indicated, according to the circumstances of the country-rock, with appended mining terms, very serviceable to working miners." The old instruments referred to, are represented by Figs. 2 and 3,

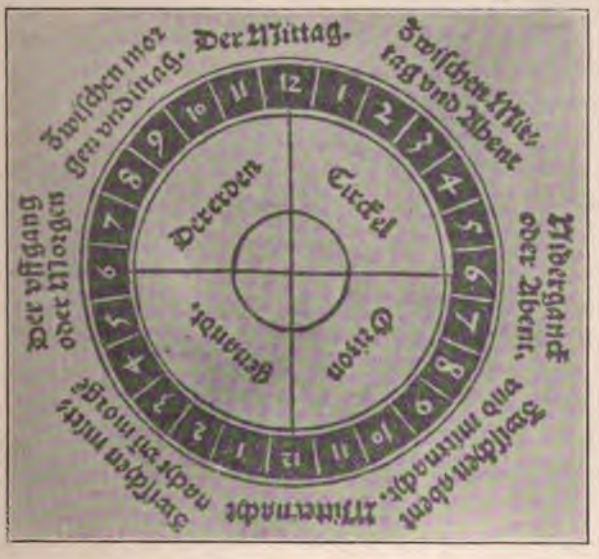


FIG. 2.—MINE-SURVEYING COMPASS, 1504 TO 1515.

the first of which seems to be the oldest form. The exterior circles, engraved upon it, are divided by lines representing the four cardinal points, and the first, or meridian-line, indicated mid-day to mid-night, and, consequently, the right-hand half of the circle is divided from 1 to 12 hours, and the left-hand of the circle, or from mid-night to mid-day, is also divided from 1 to 12 hours. It would seem that Fig. 3 is an improved variation of Fig. 2; it has a double set of circles and, also, a double set of figures on the same plan as Fig. 2. A magnetic needle was

* *Transactions of the American Institute of Mining Engineers*, 1901, vol. xxxi., pages 25 and 716.

also mounted at the centre of the instrument. Without doubt, when in use, the needle must have been pointed to 12 hours as a zero-point, and then the direction of any underground road must have been indicated by stretching a string or cord over the instrument and along the road or excavation, the division then cut upon the instrument by the cord being noted. Any bearing or intermediate direction between the hours must have been estimated. The surveying-instruments represented by Figs. 2 and 3 are older than any of the instruments described by Mr. Scott, in his American and British papers upon the subject.

FIG. 3.—MINE-SURVEYING COMPASS, 1515 TO 1518.

The paucity of books on mining and mine-surveying in England prior to the time when Houghton wrote in 1681, or in the olden times, is a very remarkable circumstance; but considering that book-learning and the art of writing books were chiefly confined to the higher dignitaries of the Church, and in Latin, it is not so surprising that those of that period, occupied in mining and mine-surveying, were so little adapted to convey their ideas and practice in writing. Neither was the German language common in England from the time of Houghton, to that of Fenwick and Budge. It is not, therefore, probable that German scientific literature had any influence upon English mining men in the sense of providing means of instructing them

in mathematics and the art of land and mine-surveying. Setting aside, for the sake of argument, Reinhold's early work, and the chapter on mine-surveying in Agricola (1556) as foreign productions, Houghton would appear to be the first English writer upon the subject of mine-surveying, in 1681, some five years before Voigtel wrote in 1686; but the latter work is of a distinct class from the former. From 1681 onwards, many works upon surveying appeared in England, some of which contained tables of logarithms and sines, for co-ordinate purposes.

Special works dedicated exclusively to mine-surveying were very limited, compared with the importance of the subject; and it is probable that, down to a comparatively modern period, practical surveyors may have considered that some of the principles, laid down in land-surveying books, were sufficient and could be applied to underground surveying. Mr. Scott's appreciation of Fenwick, 1804, and Budge, 1825, is correct, and it is pleasing that he has accorded to them the merit which they so much deserve. How absurd is the idea that Budge's book is considered by only a single individual as "dealing only with the mines of Cornwall!" He (Mr. Hoskold) had always maintained that, as a system of magnetic or dial-surveying, Fenwick's book would never be superseded; besides he was the first to indicate the plan upon which the present English system of theodolite-surveying in mines is based. Baker, the civil engineer, had so great an estimation of the value of Fenwick's *Mine-surveying*, that he published a new edition of it in 1877.

Since he (Mr. Hoskold) published his practical system of mine-surveying in 1863, various notices upon mine-surveying have appeared. An excellent chapter on this subject will be found in Mr. Caleb Pamely's *Colliery-managers' Handbook*, 1898, and of the few works exclusively devoted to it a recently-published book is highly to be recommended.*

In his American and English papers, he (Mr. Hoskold) had already expressed his opinion upon the new instrument introduced by Mr. Scott; but he did not wish to occupy the invidious position of comparing his new civil and mining engineers' transit-theodolite with that of Mr. Scott, because he believed that it was far preferable to allow each instrument to rest upon its own merits, and to be appreciated and judged, after use, by practical men.

* *A Practical Treatise on Mine-surveying*, by Prof. Arnold Lupton, Longmans and Company, London, 1902.

There was ample evidence that all instruments in England, which could be applied to mine-surveying, have been, more or less, changed in form to suit various ideas and conditions, from the old plain magnetic dial in Stones' (Bion's), 1723, to the present time, and, in some instruments, such changes have involved important inventions. This remark may be claimed to apply to the very popular instrument called the Hedley dial-circumferentor, in its various forms as presented by different makers, as also, to other instruments, but such changes can only be summed up as improved means to facilitate and obtain a particular end, that is, to offer more or less advantage in accuracy, speed and ease in observing magnetic bearings, and horizontal and vertical angles; but this does not alter the scientific base of a principle upon which a practical system of mine-surveying rests. The how, and in what manner, mine-surveys should be best conducted, depends upon the application of unalterable mathematical principles, that is, the principle of doing a given kind of work is one thing, but the instruments by which it is to be effected is quite a different thing. It cannot be doubted that the instruments produced in modern times for all classes of surveying operations, by the well-known and long-established firms of Messrs. Troughton & Simms, Elliot Brothers, Cary, Stanley, Stewart, Casella, Archbutt and others in London; Messrs. John Davis & Son of Derby, and Messrs. Cook of York, etc., cannot be excelled by a similar class of production in foreign countries, and, for these reasons, foreign surveying-instruments are not necessary or employed in England, India, or the British Colonies. Besides, British instruments are preferred in the Argentine and other South American republics. Without prejudice, or entertaining the slightest intention to affect or injure the susceptibilities of those who are meritorious and have claims to the greatest considerations, he (Mr. Hoskold) believes that this notice contains confirmatory evidence, of an absolute character, proving the hard-earned, well-merited and long-established credit of the British people in reference to the particular subjects which have been brought forward and discussed.

Under the conditions presented, therefore, it must be considered to be an unhappy circumstance and "sincerely to be regretted," that Mr. Bennett H. Brough had entered upon the unusual course of a rejoinder* to his (Mr. Hoskold's) reply to

* *Trans. Inst. M.E.*, 1902, vol. xxiii., page 620.

Mr. Brough's criticisms upon the paper "Notes Upon Ancient and Modern Surveying and Surveying-instruments," etc. This criticism, occasioned by Mr. Scott's paper and the remarks thereon, exhibits, in the clearest manner, that his (Mr. Hoskold's) opinion, formerly expressed in the passage alluded to, and so distasteful to Mr. Brough, is not only based upon and justified by the circumstances and antecedents of the case; but upon experience and close observation extending over a period of more than half a century. It is quite possible that a few of those who have been devoted merely to scholastic pursuits may have acquired, and enriched themselves by, the knowledge circulated in foreign countries; but he (Mr. Hoskold) was thoroughly convinced that Englishmen, as a rule, had not received so much valuable assistance and instruction in mathematics, other sciences, inventions and construction of instruments, and in the art of land and mine-surveying as Mr. Brough, and a few others of his way of thinking, would lead us to believe.

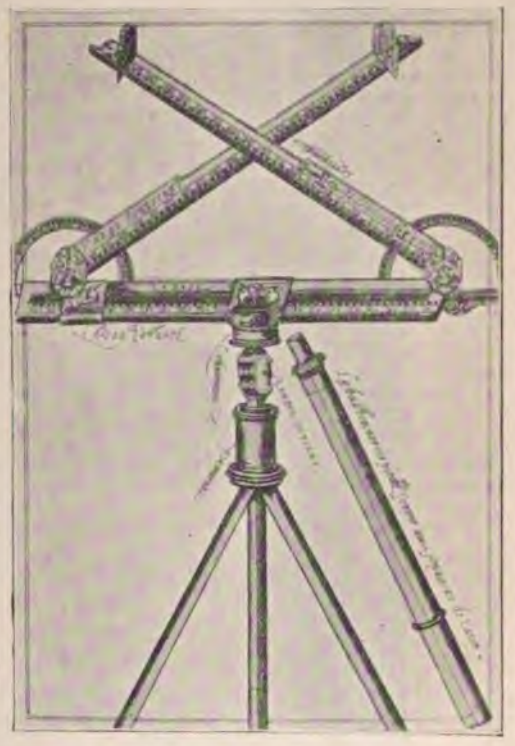


FIG. 4.—THE DAUFRIE TRIGOMÈTRE, 1597.

In an excellent work previously noted,* an old surveying-instrument is illustrated and called trigomètre, originally existing in a work of Daufrie, 1597, and reproduced in Fig. 4. Colonel Laussédat is of opinion that Daufrie invented the instru-

* *Recherches sur les Instruments*, etc., by Col. A. Laussédat, Paris, 1893, page 79.

ment, and it appears that it was intended to be employed fo finding distances.

When re-arranging his library, some time ago, he (Mr. Hoskold came upon some old Italian scientific literature, and an examina

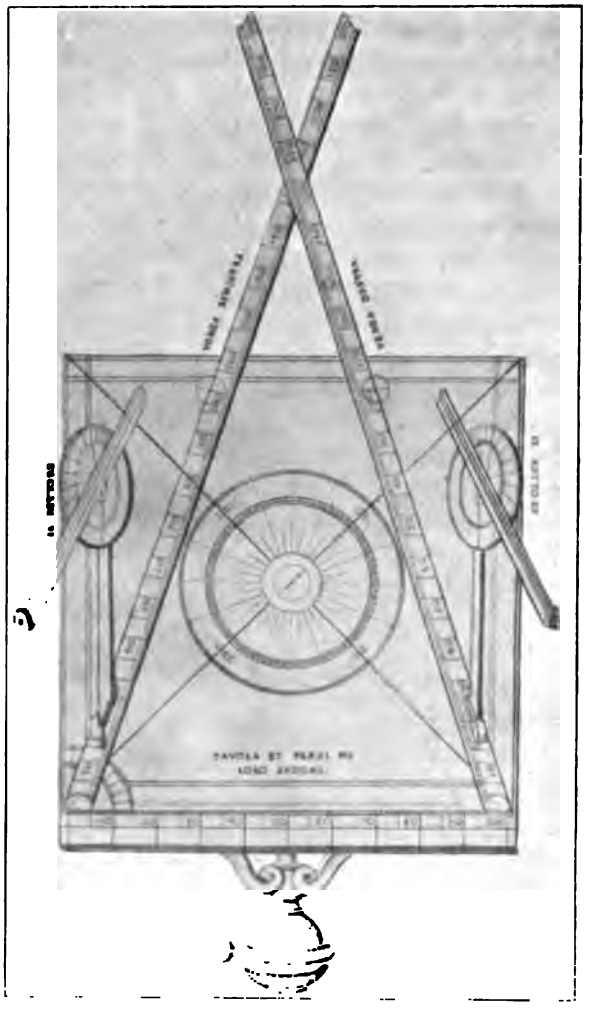


FIG. 5.—THE HOLOMETRO, PRIOR TO 1564.

tion of one of the books published by Zilleti, at Venice, in 1564 brought to light a very old and curious instrument, also used fo measuring distances. It is represented by Fig. 5, and is termed *holometro*. Zilleti says, " Having come into my hands, the presen

work is translated into our language (Italian) from the French, by a gentleman of this city for amusement, and as it appears to me to be useful, I desire to publish it." From the description given, it is clear that the original work by Fullone was written in French, and considering that he was a valet of the King of France, he must have been a favourite of Catherine de' Medici. It is prob-

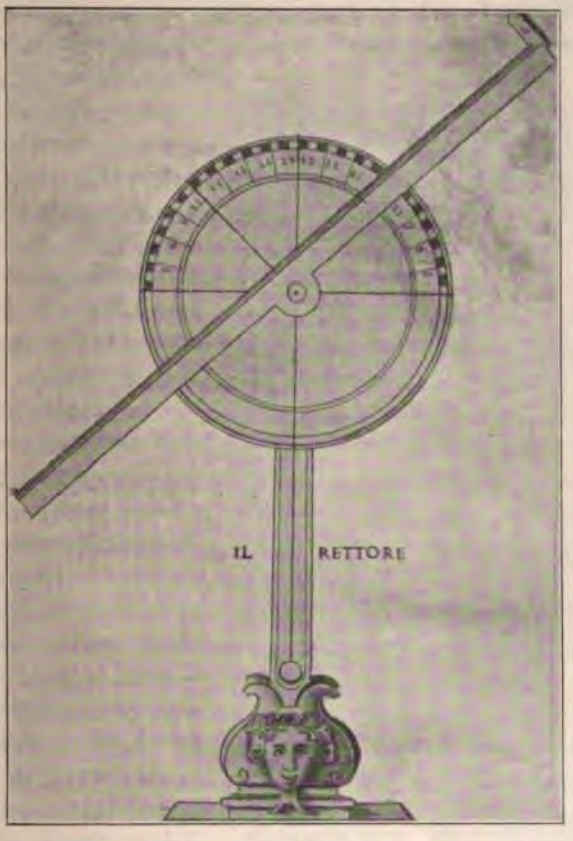


FIG. 6.—THE STAND AND VERTICAL CIRCLE OF THE HOLOMETRO, PRIOR TO 1564.

able that he invented his holometro and produced his work describing its use somewhere between 1540 and 1564. This instrument is at least 33 years older than that of Daufrie, and probably it may have been the original form from which Daufrie's instrument was constructed. Fig. 5 represents the holometro, which consists of a square base of metal, or of wood, with a magnetic compass mounted at its centre. One of the sides of the square, or

the lowest in the diagram, was divided into 100 equal parts, as seen in the engraved base-scale, and, upon each of the ends of the base, a long divided bar or rule was mounted, upon a pin or axis. Each of the extended rules or bars, revolving on an axis, was divided into 190 equal parts. At the point represented by the division of 100 upon each rule, a joint was formed, so that the rules could be bent to fit the sides of the square or instrument for convenience of packing and carriage. Fig. 6 represents the leg or stand, at the upper part of which a divided circle was mounted upon an axis. A long bar with plain sights was also mounted upon the same axis, and revolved vertically round the circle. The lower end, of the leg or stand, had a base in the form of a dovetail, and when the holometro was in use, this part was inserted into a corresponding dovetail groove made between the thirteenth and twenty-eighth division of the long rules or bars; consequently there were two vertical stands, or legs, with circles and plain sights, one of which was placed on each of the horizontal bars when the instrument was in use. When the holometro was placed upon its common stand for use, it was levelled by means of a plumb-line suspended from the centre of each of the vertical circles. The zeros of the vertical circles were also determined in the same manner. Fig. 6 indicates that only the upper half of the circle was divided; but the Italian text describes the circle as being divided round the whole circumference.

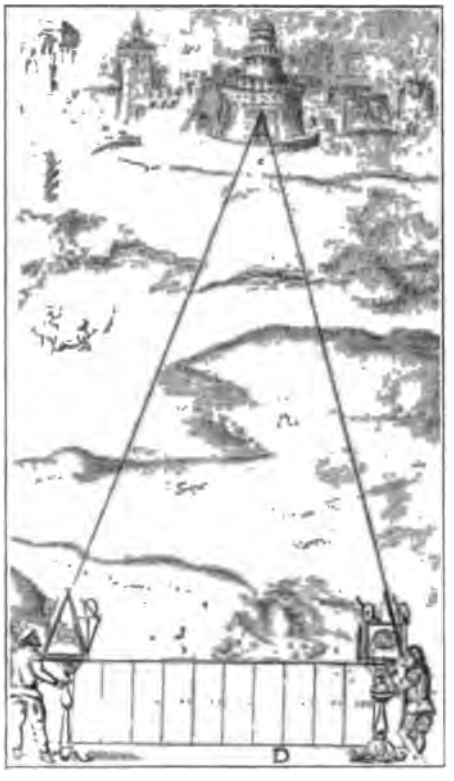


FIG. 7.—METHOD OF USING THE HOLOMETRO, PRIOR TO 1564.

It appears from the Italian description that, when a distance had to be determined, the operation was carried out as shewn in Fig. 7. A base-line of 100 units was measured on the ground, and the instrument set up at the first or right-hand station, and the line forming the divided side of the instrument was directed so as to coincide with the second, or left-hand station. Then a sight was taken by means of the plain revolving sights of the right-hand bar, which moved with it, to the extreme point at C. The magnetic bearing was then read, and the right-hand bar was allowed to remain in its position. The instrument was then removed to the second or left-hand station and the needle of the compass made to point to the same bearing as that noted at the first station, which operation would bring the line forming the divided base of the instrument in the direction of the first station. The left-hand plain revolving sights to the second vertical circle, were then directed to the point C, and the divisions cut by the crossing point of the two divided bars indicated the length of the two lines observed. When the distance was so great that after sights had been taken to the distant object, the divided bars would not cross each other; the left-hand bar with its divided quadrant was slidden along the metallic base in order to diminish the distance from 0 to 100, until the two bars would cross each other; the plain sights of each being directed at the same time to the distant object. The distance was then found by the rules of proportion. Great interest is attached to this instrument, for the reason that the vertical circle and plain sights, mounted upon a leg or stand, as shewn in Fig. 6, afford evidence that the present principle of mounting surveying transit-theodolite circles is more than 340 years old. The only difference is that the old vertical circle of 1564, exhibited in Fig. 6, was suspended and supported upon an axis at one point, instead of at two points as in present practice; but there is no doubt that the latter was derived from the former.

The Italians also practised other curious modes of finding distances by means of geometric squares, and other classes of instruments at an early date* as the footnote shows.

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* (1) *Libro del Misura con la Vista*, by Silvio Delli Vicentino, Venetia, 1566; and (2) *Monicometro Instrumento da Misurar con la Vista*, by Francesco Pifferi, Siena, 1595.

DISCUSSION OF MR. H. LIPSON HANCOCK'S PAPER ON THE "MINING AND TREATMENT OF COPPER-ORE," ETC.*

Mr. H. Lipson Hancock (Moonta Mines, South Australia) wrote that following mechanical concentration and smelting, the wet treatment of vein-stuff containing sulphide copper-ores (especially those associated with iron-pyrites, and these were probably more common than those that were free from the latter mineral) was essentially required, and present-day experience was proving that this style of treatment would be more widely adopted in the future than it had been in the past. It had gradually grown in connection with the operation of the Wallaroo and Moonta mines, and he hoped at an early date to attain an extraction in this department of over 2,000 tons per year, providing an ample supply of acid is available. Of course, this output would be obtained from treating a large quantity of crushed vein-stuff, which had accumulated during a number of years; nevertheless it indicated the importance attaching to the process. There was no doubt that this means of extraction, in which the assistance of sulphuric acid played an important part, would be still further improved.

He (Mr. H. Lipson Hancock) might repeat that the tailings at the Moonta mines are chiefly felsite-porphyry, with a small percentage of copper-pyrites and a little bornite. The assay for copper in recent years was about 0·7 or 0·8 per cent., although the average of the full heaps under lixiviation might be set down at 0·9 per cent. There is only a very small percentage of iron-pyrites in the material of the Moonta mines under treatment, so that it causes a dearth of iron in the liquors. In order, therefore, to facilitate the leaching operations, it will be necessary shortly to use a small percentage of sulphuric acid; this will enable the liquors to attack the proto-salts of copper as they are formed, and lead to higher extraction. New tailings from the concentrating plants, after dumping, are periodically soused for some weeks, and then allow to rest for 3 or 4 months, according to circumstances. They are then drenched again; and, after a further short rest, they are generally in a sufficiently oxidized state for leaching, as indicated above.

The precipitate is washed against a stream of fresh water, and

* *Trans. Inst. M.E.* 1901, vol. xxii., page 461.

divided into three classes, the coarser and heavier being separated as the best. The first and second classes are melted in a reverberatory-furnace, with other coarse copper from the concentrating ores. There is only a small percentage of the third-class precipitate, and this has to pass through two furnaces in the smelting. There was, he might say, a freedom from impurities in the material, and good copper known as the Wallaroo brand resulted therefrom.

DISCUSSION OF MR. J. J. MUIR'S PAPER ON THE "TREATMENT OF LOW-GRADE COPPER-ORES IN AUSTRALIA."*

Mr. H. Lipson Hancock (Moonta Mines, South Australia) wrote that there is no doubt that sulphuric acid is useful in connection with the wet treatment of sulphide ores of copper, especially when oxidation has more or less set in. This may be the result of natural weathering, but it is generally a slow operation. If, however, the ore be properly dumped and soused periodically with liquors containing salts of iron, and is allowed to rest and dry for some time, oxidation is very much promoted. Sulphuric acid applied at this stage is a powerful solvent, and its use has led to very satisfactory results.

DISCUSSION OF MR. F. J. NORMAN'S PAPER ON "BORING IN JAPAN."†

Mr. F. J. Norman (Calcutta) pointed out the following errata in his paper:—On page 685, line 6 should read "depths of 300, 480 and 720 feet below sea-level, and the depths increase the farther one goes inland." On page 690, line 8 should read "depth of from 5 to 8 feet," etc; and line 13, "bottomless tub or box," etc. Page 691, line 17 should read "(*Zelkowa acuminata*)."

Mr. William Charlton read the following paper on the "Use of Ratchet and other Hand-machine Drills in the Cleveland Mines":—

* *Trans. Inst. M.E.*, 1902, vol. xxiii., page 517.

† *Ibid.*, 1902, vol. xxiii., page 685.

USE OF RATCHET AND OTHER HAND-MACHINE DRILLS IN THE CLEVELAND MINES.

By WILLIAM CHARLTON, Assoc.R.S.M.

Some twenty years ago, almost the whole of the Cleveland ironstone was won by the chisel-pointed hand-drill, with a swelled end to add weight to the blow, and well known to all interested in mining as the "jumper-drill."

Fig. 8.—Hardy Ratchet Drilling-machine.

So established had this mode of drilling become that the old practical miner of that time naturally considered it necessary for working the Cleveland stone that the holes should have the triangular shape △, and that it was only by his skill in drilling, with the jumper-drill, a hole with a "flat-back" or "flat-front," "flat-top," or "flat-bottom," that the stone could be successfully mined.

Experiments, however, had been made with rotary drills, which showed conclusively that a round hole could work the stone; and the millions of holes which have since been drilled by the compressed-air and electric drills, so successfully introduced by Mr. William Walker and Mr. A. L. Steavenson, are more than ample proof of their suitability.

FIG. 9.—PENDULUM DRILLING-MACHINE.

Since 1880, mining by power-machines has made great progress and at the present time about one-third of the Cleveland ironstone is won by such machinery.

Until 1888, very little use had been made of the hand-machine drills. The late Mr. George Lee had tried some at the Liverton mines, and the late Mr. T. Allison, of Guisborough, had introduced a few ratchet-machines into the Belmont and Spawood mines of the Weardale Iron & Coal Company, Limited.

In 1884, owing to depression in the iron-trade, the Slapewath mines of Sir B. Samuelson & Co. were closed. It being absolutely necessary that steps should be taken to reduce the cost of winning the ironstone, on restarting the mines in 1886, a thorough and exhaustive trial of the ratchet-machine was instituted. The first machines were of crude construction, being fitted with loose

FIG. 10.—GRAY-TARBIT ROTARY DRILLING-MACHINE.

brasses in the barrel and thick-edged drills; and, when drilling the hole, the machine was set against a prop fixed between the roof and the floor.

It was soon found that a great drawback to the use of the machine was the time spent in setting these props or stands, a considerable portion of the time saved in drilling the hole being spent in the preliminary setting of the props and in changing the drills. In many instances, the stone thrown down by the

previous shot would be lying where the prop should stand; and in other instances, owing to projections of the side of the working-place, the prop could not be set near enough to the side to obtain the right direction of the hole. It became necessary, therefore, to supplement the prop with a cross-bar of iron between it and the side of the place, the end of the machine resting against this bar. Old permanent-way fish-plates were found to be suitable for this purpose. For convenience, they were pointed at one end to make the bar fit better against the stone, the other end being fastened by a nail to the prop.

FIG. 11.—GRAY-TARBIT ROTARY DRILLING-MACHINE.

After a time, this pointed end was driven into a recess made in the stone, and it was found to fasten itself so well that when a stronger bar of iron was pointed with a chisel-end and driven into a hole made about 1½ inches deep, by a pick, it was sufficiently firm to stand the thrust of the machine without the aid of a prop to support the other end.

This discovery, at once, very materially increased the facilities of working, and may be said to have brought about the success which has attended the use of this mode of drilling in the Cleveland mines. It rendered unnecessary the props or stands which

were hitherto used, and made it possible to fix the machines so that the holes were drilled in the very best position for the advantageous blasting of the stone.

Figs. 1 and 2 (Plate XV.) show the pointed bar, *a*, of iron driven into the side of the place, and the ratchet-machine set for drilling; *b* is the barrel of the drill; *c*, the nut-collar; *d*, the screw-spindle; *e*, the ratchet; and, *f*, the drill-end. The bracket or bar is chisel-pointed at *g*, and is formed with a number of holes, or countersunk recesses, *h*, for receiving the barrel-end, *i*, of the drill.

FIG. 12.—HALL ROTARY DRILLING-MACHINE.

A remarkable development of the means employed to take advantage of the property possessed by the stone of holding fast the bar of iron driven into it is shown in Figs. 3, 4 and 5 (Plate XV.), a modification designed for use in starting or turning-away places at right angles to the winning-place. The long bar, *a*, is chisel-pointed at the end, *g*, *j*, is a short bar with holes or countersunk recesses, *h*, and with a socket, *k*, capable of sliding on the bar, *a*, to any convenient position. Other modifications will be seen in the illustrations or photographs of the machines in working positions.

While progress was being made in the manner of setting the machines, improvements in the machine itself were not neglected. Clasps were substituted for the loose brasses in the machine shown in Fig. 1, and some time afterwards these were discarded for the improved ratchet-machines of the Hardy Patent Pick Company with the Stayner split-nut (Fig. 6, Plate XV.) for the quick withdrawal of the drills (Fig. 8).

A lighter and fish-bellied section of drill-steel was procured, which proved to be a great improvement; and, combined with these, it was found that a square-topped screw with

FIG. 13.—BLACKETT-HUTTON ROTARY DRILLING-MACHINE.

4 threads to the inch, instead of a Whitworth screw with 7 threads to the inch, whilst increasing the speed of the drilling by 75 per cent., scarcely, if at all, increased the labour.

To obtain the benefit of the weight of the handle and the advantage of the pulling-down stroke when the drill is advancing, which is the case with the machine in the position shown in Fig. 1 (Plate XV.), machines with left-handed screws and drills were obtained for use when the holes were to be drilled on the other side of the working-place (Fig. 8). Each pair of workmen was supplied with two machines, thus enabling them to use the machine best suited to the situation.

Many other devices of machine have been tried, such as the pendulum-machine (Fig. 9), which by an arrangement of bevel-wheels gave a cutting stroke at each stroke of the handle; the double-handled ratchet-drill (Fig. 7, Plate XV.), and others.

Passing over these, a great advancement was made by the introduction of hand rotary machines for drilling the softer stone; and Messrs. Gray & Tarbitt's machine was introduced at the South Skelton mines (Figs. 10 and 11).

Fig. 14.—Hardy Rotary Drilling-machine.

Mr. William Hall's machine is in use at Messrs. Pease & Partners', Skinningrove and Upleatham mines (Fig. 12); and Mr. C. Heslop's machine, more suited to the harder stone, is used at their Lingdale mines. Mr. John Martin, a working miner, introduced a simple, but useful rotary machine at the Skelton mine. Messrs. Blackett, Hutton & Company, the Hardy Patent Pick Company and Messrs. John Livingston & Sons have a large number of their machines in use at several of the Cleveland mines (Figs. 13, 14 and 15).

Fig. 16 shews a miner using a jumper-drill.

Among those who have given so much thought and attention to the development of drilling by ratchet and hand rotary machines

in the Cleveland mines, the names of my assistants, Mr. James Thompson and Mr. William Brooks, deserve particularly to be mentioned.

The usual practice of Cleveland hand-mining is for two miners to work together as mates, one man drilling the holes, charging and firing the shots, while the other man breaks up and fills the stone into the tubs or wagons.

Many experimental trials have been made to ascertain the relative time occupied in drilling by the jumper-drill, the ratchet,

FIG. 15.—LIVINGSTONE ROTARY DRILLING-MACHINE.

and the hand rotary machine, and in some cases very remarkable results have been obtained. Not wishing to exaggerate the value of the ratchet or hand rotary machines, the writer is keeping well within the mark in stating that two holes can be drilled with these, to one with the jumper-drill; and that, under ordinary conditions, the output per shift of the pair of men can with ease be increased fully 20 per cent.

In addition to this advantage, the diminished amount of physical labour, required in working these machines, enables men to continue mining, who would have been compelled to abandon it, if restricted to the jumper-drill; and it also allows youths,

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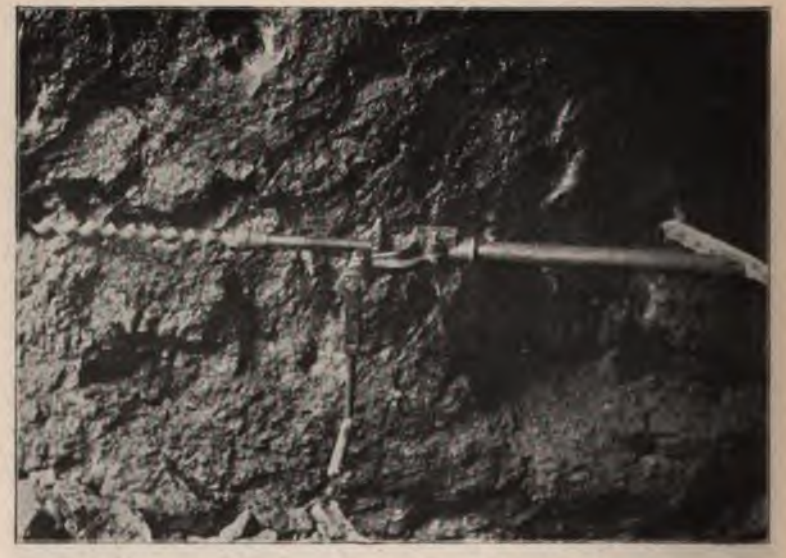

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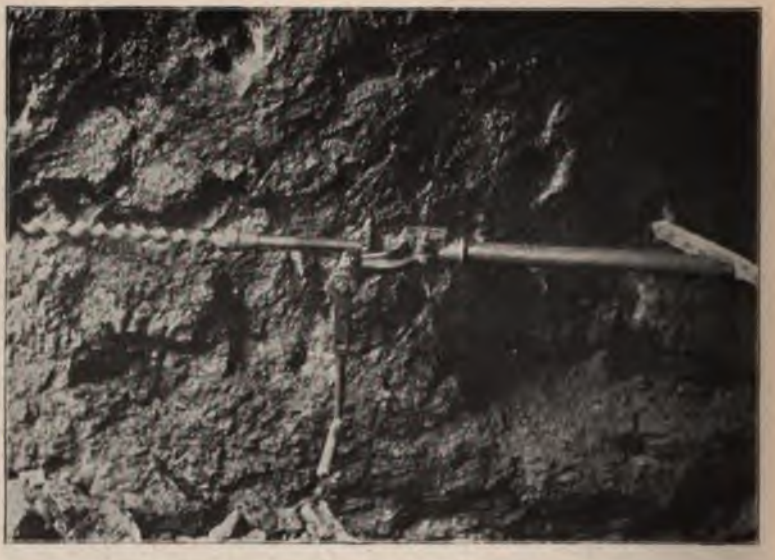

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In addition to this advantage, the diminished amount of physical labour, required in working these machines, enables men to continue mining, who would have been compelled to abandon it, if restricted to the jumper-drill; and it also allows youths,

under the direction of their fathers or other men, to engage i
mining at a comparatively early age.

Table I. shows the gradual increase in the use of ratchet an
other hand-machine drills in the Cleveland mines, in percentag
of the total output each year.

FIG. 16.—MINER USING A JUMPER-DRILL.

TABLE I.—PERCENTAGE OF THE OUTPUT OF THE CLEVELAND MINES, WROUGHT BY RATCHET AND OTHER HAND-MACHINE DRILLS.

Year.	Per Cent.	Year.	Per Cent.	Year.	Per Cent.	Year.	Per Cen
1886	0·50*	1890	2·94	1894	10·23	1898	31·39
1887	1·53	1891	2·79	1895	12·82	1899	33·46
1888	2·05	1892	3·09	1896	21·86	1900	40·47
1889	2·93	1893	5·00†	1897	28·97	1901	39·53

* Commenced using ratchet-drills at the Slapewath mines.

† Introduced at other mines.

‡ Large temporary decrease at one mine, owing to depression in the iron-trad

FIG. 2.

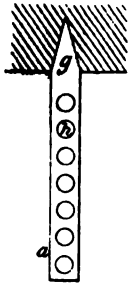


FIG. 1.

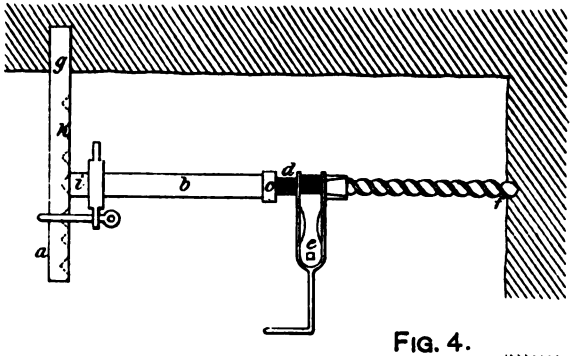


FIG. 4.

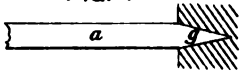
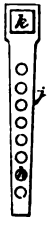


FIG. 5.



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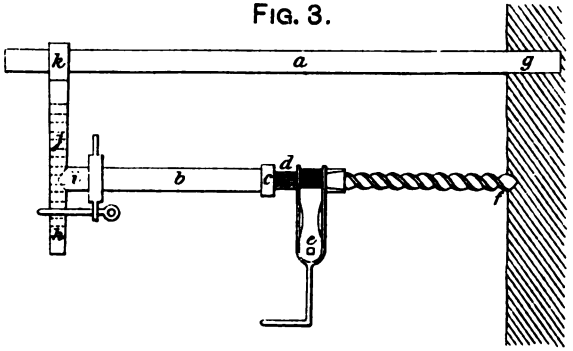


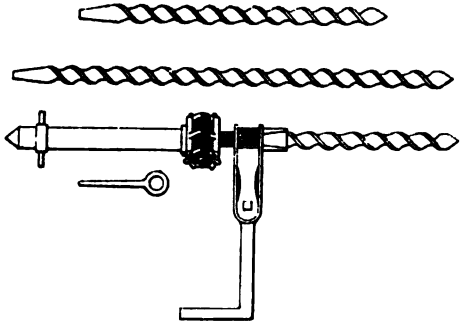


FIG. 6.—HARDY RATCHET-DRILL.

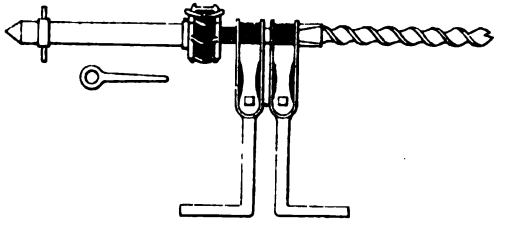


FIG. 7.—HARDY DOUBLE-HANDLED RATCHET-DRILL.

Mr. A. L. Steavenson (Durham) said that good work appeared to have been done by the drills described by Mr. Charlton, but in his opinion there was nothing equal to an electrically-driven drill, which only required one skilled man to look after it, while unskilled men could do all the other work required in connection with taking down the ore. Electric-drills were also more economical in working than ratchet-drills—good as these latter were. Many of the members had, no doubt, seen electrically-driven drills in operation at the mines in Cleveland under his charge.

Mr. N. R. Griffith (Wrexham) said that it might not be out of place for him to mention that he was driving a drift, in metals, about 2 miles long, and he was using rotary drills worked by compressed air. In hard rocks, percussive drills were used, and in shales and metals, rotary drills were used; and they changed from one system to the other, according to the nature of the strata. If rotary drills would not bore the stone, then they used percussive drills, the drills in all cases being driven by compressed air. A percussive drill did not appear to him to be a very scientific piece of machinery, because, from the nature of its action, it was knocking itself to pieces all the time that it was working. He had not had any experience with electrically-driven rotary drills, and they might possibly have a great future before them.

Mr. W. Walker (H.M. Inspector of Mines) wrote that he had read Mr. Charlton's paper with much interest, as he well remembered the introduction of rotary drilling-machines, driven by compressed air, into the Cleveland district—at Stanghow ironstone-mines about 25 years ago. At that time, it was thought, and especially by the miners, that the circular hole would not produce such good results as the triangular one, but this prejudice was eventually overcome, and at the present time, as the author states, quite one-third of the Cleveland ironstone is got by the power-machines. For some years, even after the introduction of the rotary drilling-machine, the theory that percussive drills were best suited to the mining of Cleveland ironstone was held by many of the mine-managers, and the Eclipse and other percussive machines, driven by compressed air, were introduced into some of the mines. Eventually it was decided to try the

rotary drilling-machine, in the same mine and district as the percussive machine, for a period of three months, and the result proved so conclusively the superiority of the former, both as regards the number of holes drilled and the quantity of iron-stone got per shift, that the use of power percussive drills was discontinued, and, at the present time, the whole of the power drilling-machines, whether driven by compressed air or electricity, are rotary machines drilling circular holes.

The methods adopted to dispense with the props, which were at first set between the roof and floor, for the ratchet-machines to be set against, are ingenious and simple, and allow of the shot-holes being drilled in the required position and direction; and, at the same time, one man can be drilling holes, while the other is filling away the stone brought down by previous shots.

One point is not mentioned by Mr. Charlton in his paper, and that is that the introduction of rotary drilling-machines was the means of bringing into use compressed powder in the shape used at all the mines in the Cleveland district and also, to a large extent, the use of squibs, both of which have no doubt increased the safety with which shot-firers and miners can do their work. In the old days, when loose powder and home-made straws were used, as they were with the hand jumper-drill, it would have been a physical impossibility for the shot-firers to do as much work as they do now, to say nothing of the increased safety. At first, compressed pellets were introduced, of the shape of the triangular hole produced by the jumper-drill; but it was found that if the shot-hole was the slightest out of truth the pellets stuck, and, in trying to force them in, many miners have been more or less injured. Afterwards spherical pellets were adopted, with such success that they have been used ever since, for both circular and triangular holes, although with a triangular hole great care has to be exercised, as it is very easy for, say, a "flat-fronted" hole to become "flat-backed," "flat-topped" or "flat-bottomed," or *vice versa*; and, if this occurs, a ledge or canch is formed, at the spot where the change takes place, in the hole, beyond which it is not possible to pass a compressed pellet without using force which is highly dangerous and a breach of the Coal-mines Regulation Act and the special rules current in the district.

Mr. W. CHARLTON, replying to the remarks of Mr. A. L. Steavenson, said that his object in writing the paper was, not to make comparisons between the work of the hand machine-drills and that of the power-drills (both electric and compressed air) so successfully worked in some of the Cleveland mines, but to show how jumper-drills were being superseded by hand-machines. He believed that, in many cases, the hand-machines were as economical as the power-machines, and he was strengthened in that belief by the figures recorded in Table I., showing the great increase in the tonnage wrought by hand-machines in recent years. In some mines, where a portion of the ironstone was won by jumper-drills, and the remainder by power-machines, the former have not been replaced by an extension of the use of the power-machines, but by the introduction of band-machines.

The PRESIDENT (Sir Lindsay Wood, Bart.) moved a vote of thanks to Mr. William Charlton for his interesting paper.

Mr. M. WALTON BROWN seconded the resolution, which was cordially approved.

Mr. C. C. LEACH read the following paper on "Superheated Steam at Seghill Colliery":—

SUPERHEATED STEAM AT SEGHILL COLLIERY.

By C. C. LEACH.

There are 5 Lancashire boilers, 30 feet long and 8 feet in diameter, 4 are worked at a pressure of 100 pounds and 1 at 40 pounds per square inch, and they provide steam for the pit and shops. When the low-pressure boiler is off, steam is passed through a reducing-valve for use at the winding-engines.

The Dixon superheater (Figs. 1 and 2, Plate XVI.), consists of 33 solid-drawn steel U tubes, $1\frac{9}{16}$ inches in outside diameter, and about 6 feet long, expanded into a steel plate to which is bolted a cast-iron box with a vertical division, which compels the steam from the boilers to enter one side of the tubes, and pass out by the other side, and through 7-inches pipes to the main steam-pipe. Each superheater has a small dead-weight safety-valve; and steel pockets for taking the temperatures of the steam on entering and leaving.

The superheaters are placed vertically, with the tubes hanging downward, in the downtake flue at the back of the boilers, the tubes being exposed to the hot gases as they leave the furnace-flues. The superheaters are carried on a cast-iron frame laid across the opening of the downtake flue.

This superheater is simple, easily fixed, easily removed, and very strong. The makers have recently tested a similar superheater to destruction. At a pressure of 400 pounds per square inch, the joint between the top box and the tube-plate began to shew signs of leakage, which increased and prevented the pressure from rising above 770 pounds per square inch. In a further test, after this joint was remade, a pressure of 900 pounds per square inch was obtained; and, after bearing this pressure for some time, the top of the cast-iron box cracked along the root of the flange.

The first superheater was put in and connected on December

19th, 1901, the pit-year ending 2 days later; 3 other superheaters were connected before the end of the following week; and superheating was thus practically started during the first week of 1902.

No alteration was made to the steam-pipes, beyond taking off the radial pipes, turning the steam-jugs round on the boilers, and coupling the superheaters to the boilers by 7 inches cast-iron pipes. An expansion-joint was taken out of the low-pressure range, and 2 radial pipes inserted, so that the plant is exactly as it was, except for these alterations.

The old covering is still on the old pipes and boilers, and in the usual state of repair: the new 7 inches pipes were covered with magnesium covering, the flanges also being covered.

Nothing whatever (except to keep things in the ordinary working repair), has been done to any of the engines, or to any part of the plant, since the superheaters were put in, so that the tests are made under the ordinary working conditions.

The chimney, $5\frac{3}{4}$ feet by $5\frac{1}{2}$ feet at the bottom, is 73 feet high above the grate, and has a water-gauge of only $\frac{1}{2}$ to $\frac{5}{8}$ inch. Mechanical stokers are used with moving bars, without forced draught.

Tests of 10 hours were made on 8 days during coal-work in November, 1901, before the superheaters were put in; and on 8 days of this year, so as to ascertain the weight of small coal burnt at the boilers; and 10 hours' tests were also made with nuts, and with duff coal. Table I. contains a summary of these tests.

Table I. compares the saving with the drawings and also with the indicated horsepower, and it may be of interest to know how the horsepower was calculated.

For each winding-engine, a separate card was taken from each end of the cylinder, and for each revolution of the wind. Each revolution was timed to $\frac{1}{3}$ second, and from this information the indicated horsepower per wind was obtained. The indicated horsepower was then calculated for any day, from the number of winds based upon the scores drawn.

The hauling-engines were indicated each tenth minute for the 10 hours of coal-work, giving the mean average pressure per revolution. Counters were fixed on the engines, and from the revolutions the indicated horsepower was calculated for each day.

TABLE I.—BOILER-TESTS, WITHOUT AND WITH SUPERHEATING OF THE STEAM.

No. of Test.	Superheating or not Superheating	Date.	Number of Boilers at Work.	Description of Coals used.	No. of Days of 10 Hours Coal-work.	Average Weight of Coal burnt per Day.	Ash.	Average Drawings	Average Per cent. of Coal used to Drawings during Coal-work.	Average Total Indicated Horsepower, Donkey-pumps and other small Engines being estimated.	Average Weight of Coal burnt per Indicated Horse-power per Hour.	Indicated Horse-power per Boiler.	Coals burnt per Square Foot of Fire-grate per Hour
						Pounds.	Per cent	Tons.	Per cent.	Horsepower.	Pounds.	Horsep'wer	Pounds.
1	Not Superheating	Nov., 1901	4	Small coals, with about 16 per cent. of rough nuts	8	31,537	12·40	1,577	0·8928	276·4	11·41	69·1	22·63
2	Superheating	Jan., 1902	4	Do....	1	29,664	14·22	1,671	0·7920	266·0	11·15	66·5	21·29
	Saving on	No. 1 Test	...	...	...	1,873	...	...	11·29	...	0·26*	...	...
3	Superheating	Jan., Feb., March, and June, 1902.	3	Do....	8	27,335	11·04	1,691	0·7218	276·2	9·897	92·1	26·16
	Saving on	No. 1 Test	1	...	...	4,202	...	...	19·15	...	1·513†	...	...
4	Superheating	June, 1902	2	Nuts	2	25,130	10·01	1,630	0·6883	285·9	8·790	142·9	36·08
	Saving on	No. 1 Test	2	...	...	6,407	...	...	22·90	...	2·620‡	...	...
5	Superheating	June, 1902	5	Duff ...	1	38,864	24·71	1,577	1·1001	281·8	13·79	56·4	22·31
	Loss on	No. 1 Test	1	...	...	7,327	...	...	23·10	...	2·38§	...	...
**6	Superheating	Feb., 1902	2	Small, with about 16 per cent. of rough nuts	1	19,656	11·86	782	1·125	211·6	9·29	105·8	28·21
	Saving on	No. 1 Test	...	...	...	...	...		...	...	2·12¶	...	...

* A saving of 2·28 per cent. † A saving of 13·28 per cent. ‡ A saving of 22·95 per cent. § A loss of 20·8 per cent. ¶ A saving of 18·58 per cent.
** Pit only partly at work, i.e. Yard and New Blake Seams.

The fan, pump and electric engines are doing constant work. These were indicated several times and the averages taken, and for the time that the engine was running the power was divided over the 10 hours.

The shop-and-screen engines were indicated every 5 minutes for an hour, and the number of revolutions per minute was taken from the counters.

The power of the two donkey-pumps, stoker, gas, upcast-shaft engine, and steam-hammer, all very small engines, was estimated.

Superheating has enabled the colliery to be worked by 3 instead of 4 boilers, burning the same class of small coal.

The percentage of the coal that is burnt, calculated on the drawings, does not agree with the percentage calculated from the indicated horsepower; nor should it do so, because however the drawings may vary, certain of the engines, such as the fan, run at a uniform horsepower.

Superheating with 4 boilers only effected a saving of 2·28 per cent. of the coals burnt per indicated horsepower per hour, but with 3 boilers the saving was 13·26 per cent. This saving is apparently due to the extra heat obtained in the flue by burning more coal per square foot of grate per hour, and having only 3 instead of 4 boilers to keep hot.

TABLE II.—WATER COLLECTED FROM STEAM-PIPES AND TRAPS.

Outside Surface of Pipes.	Average Weight of Water per Hour.	Weight of Water per Hour per 100 Square Feet of Pipe.	Temperature of Air.
Square Feet.	Pounds.	Pounds.	Degs. Fahr.
2,763	813	29·4	53 Not Superheating
3,036	391	12·8	52 Superheating
Saving by Superheating.	422	16·6	

Superheating with 2 boilers shewed a saving of 22·96 per cent.: this further saving being probably due to the same causes.

The water collected from the pipes and engine-jackets at each steam-trap was averaged for the day; and Table II. records the averages of 5 days.

To ascertain the degree of superheating, the temperatures were taken by 2 mercurial thermometers, tested and corrected at Kew: the steel pockets in the superheaters and engines, being filled with mercury, and the thermometers placed in them. The flue-temperatures were taken by a mercury-thalpotassimeter in the downtake-flue.

The diagram (Fig. 3, Plate XVI.) shews the constant variations of temperatures observed, each minute for an hour, both of the flue and of the steam, for one set of readings. The bars were moving, and the boilers were hand-fired, with a mixture of small coal and 16 per cent. of rough nuts. Table III. contains a summary of the temperatures of the flue and superheater, observed under different conditions: the average of the observations taken at intervals of one minute being recorded.

TABLE III. – TEMPERATURES OF THE FLUE AND SUPERHEATER.

Date	Kind of Coal.	Number of Boilers Working.	Average Temperature of Flue.	Average Temperature of Superheated Steam.	Average Temperature of Saturated Steam.	Degrees of Superheat	Duration of Test.
1902.			Degs. Fahr.	Degs. Fahr.	Degs. Fahr.	Degs. Fahr.	Minutes.
July 16	Small with about 16 per cent. of rough nuts	4	942	510	338	172	60
May 22	Do.	3	966	479	337	142	60
,, 23	Do.	3	972	475	339	136	60
, 23	Do.	3	922	518	339	179	60
June 16	Nuts from Blake Seam	2	1,086	469	335	134	104
,, 19	Nuts from Yard Seam	2	1,122	475	336	139	60
,, 18	Duff	5	837	498	337	151	60

The highest temperature of superheated steam observed at the superheaters was 555° Fahr., when 4 boilers were working, fired with small coal and about 16 per cent. of rough nuts.

Table IV. shews the amount of superheat and the temperature of the steam at the various engines, and also the distance of each engine from the main steam-range.

It may be mentioned that, owing to the increase of temperature of the steam, better cylinder-oil has been used. During the first half-year of 1901, the engines used 144 gallons of cylinder-oil, costing, at 1s. 5d. per gallon, £10 4s., and during the first

To illustrate Mr. C.C. Leach's Paper "Seghill Colliery." 1 4)

DIXON SUPERHEATER.

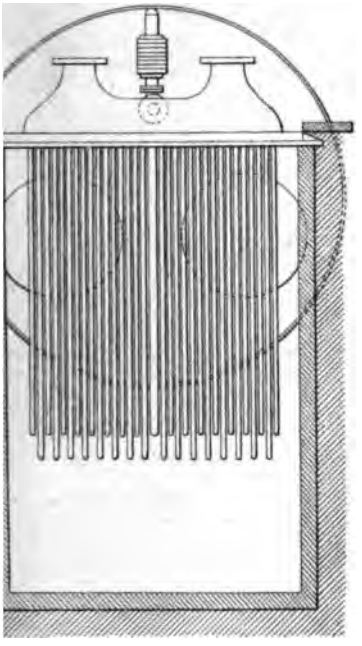


FIG. 1.—SIDE-ELEVATION.

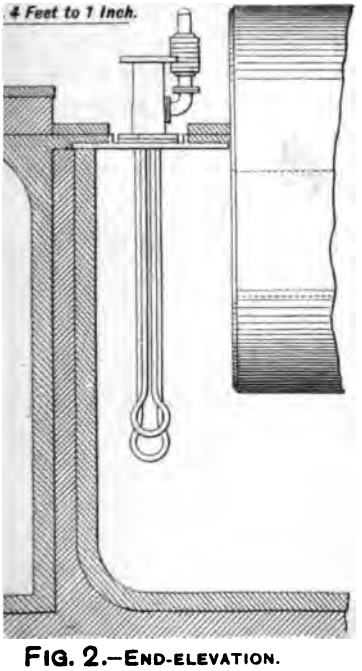
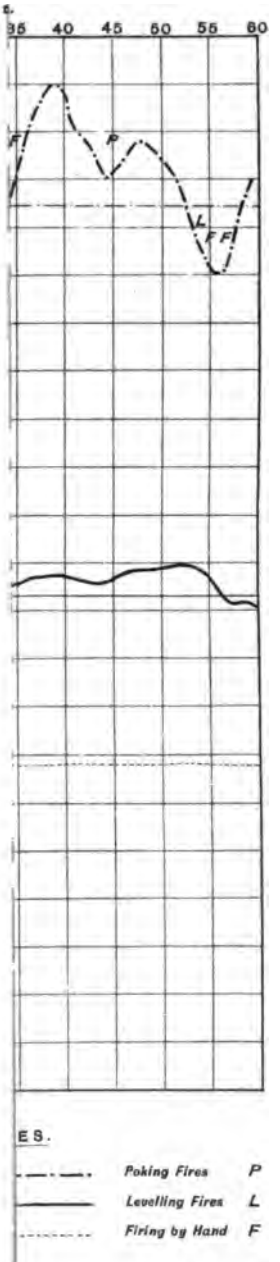


FIG. 2.—END-ELEVATION.

FIPONDING TEMPERATURES OF THE ND OF SUPERHEATED STEAM,), 1902.



half-year of 1902, when superheating, 136½ gallons of oil were used, costing, at 1s. 9d. per gallon, £11 18s. 10d. This oil has a flash point of 532° Fahr. in the close test.

TABLE IV. SUPERHEAT OF THE STEAM AT THE VARIOUS ENGINES.

Engine.	Distance from Main Steam-pipe.	Greatest observed Temperatures at Engines.	Degrees of Superheat at each Engine in 1902.					
			June 10th.	July 2nd.	July 4th.	July 7th.	Total.	Average
	Feet.	Degs. Fahr.	Degs. Fahr.	Degs. Fahr.	Degs. Fahr.	Degs. Fahr.	Degs Fahr.	Degs. Fahr.
John Pit: Winding-engine	106	308	24	11	18	14	67	16·8
Engine Pit: Winding-engine	149	278	– 3	0	– 3	0	– 6	– 1·5
Fan-engine	108	374	34	35	26	32	127	31·8
Pumping-engine ...	46	385	43	47	39	43	172	43·0
Yard Seam: Hauling-engine	201	355	16	4	6	9	35	8·8
Blake Seam: Hauling-engine	151	373	34	21	34	10	99	24·8
Screen-engine	104	358	– 2	2	– 1	– 4	– 5	– 1·2
Shop-engine	618	333	– 5	– 6	– 15	– 6	– 32	– 8·0

NOTE.—Where a minus sign occurs in this table, the superheat of the steam has been lost, and the lower temperature is due to the pressure of the steam having fallen.

There has been no breakdown of any kind, and the cylinders when examined have shewn no ill effects whatever with the above oil; but it should be noted that all the engines are recent ones, with the exception of the two winding-engines, and none of the larger engines have slide-valves.

Mr. H. C. PEAKE (Walsall) asked whether it had been found necessary to make any alteration in the engine-packing, and, if so, what packing was now used; and what was the approximate cost per boiler of the superheaters.

Mr. J. A. G. ROSS (Newcastle-upon-Tyne) asked whether he correctly understood that there was 20 per cent. of loss from the use of superheated steam with 5 boilers. If so, it was extraordinary, because the generally accepted idea in both theory and practice was that considerable economy was attained by the use of superheated steam; but the great heat imparted to the steam, involved the necessity of high pressures and the use of metallic packing. From Table I., it appeared that with 2 boilers there

was a saving of 22·96 per cent.; with 3 boilers, 13·26 per cent.: with 4 boilers, only 2·28 per cent., and if that curve were continued, they would soon have the extraordinary result that there must be a tremendous saving by having no boilers. A great advantage accompanying the use of superheated steam was not merely the economy, but the advantage in the expansion of the steam. When used in a highly expansive way in the cylinder, the terminal pressure was maintained, and that allowed the initial pressure to be reduced; consequently a lower boiler-pressure could be used, and the various parts of the engine were subjected to lower strains.

Mr. T. H. Bailey (Birmingham) enquired as to the quality of the water, and whether the pipes of the superheater had been "furred."

Mr. P. Kirkup (Birtley) asked whether the same kind of packing was used for the steam-pipes, and what was the distance from the superheaters or from the boilers to the engines. In modern steam-practice, it was important, when steam was superheated, that the engines should be placed as near as possible to the superheater. He further asked whether any of the engines were compound and condensing.

Mr. H. R. Hewitt (H.M. Inspector of Mines, Derby) said that it was generally understood that superheating and drying of steam produced economical results, and he was surprised that they were not more generally adopted. Could Mr. Leach explain which was the most economical system:- Working 5 boilers burning slack, and no superheating, or working 2 boilers with superheating, and burning nut-coals? The results would have been more reliable if all the small engines had been indicated, avoiding the necessity of estimating their horsepower, as it is well known that small engines are wasteful users of steam. He presumed that Mr. Leach took the diagram for each revolution of the winding-engine on each stroke of succeeding winds, the first stroke of the first wind, and the second stroke of the second, and so on to the end.

Mr. R. E. Ornsby (Seaton Delaval) asked what was the saving, after allowing for interest on capital and depreciation, and reckoning small coal at 5s. per ton.

Mr. W. C. Blackett (Durham) appreciated the amount of hard work involved in making the lengthy experiments which had been recorded in the paper. The subject was a very practical one, and he would be glad to hear the experience of other gentlemen, who had introduced superheating plant at collieries. He asked whether it had been found necessary to make any enlargement of the flues when erecting the superheaters.

Mr. G. A. Mitchell (Glasgow) asked whether any experiments had been made with 3 boilers, working without superheating, which could be compared with the figures when superheating; and whether the chimney was of sufficient size to give full work to the boilers.

Mr. J. W. Fryar (Mansfield) said that as he was using superheated steam, Mr. Leach's paper was of great interest and value. He had experienced difficulty, with superheated steam, in getting the superheat from the boiler to the engine. In a new plant which he had recently erected, superheaters similar to those mentioned in the paper were employed, and although in many cases he had as much as 600° or 700° Fahr. at the superheater, at the engine, 30 or 40 feet distant, there was practically no advantage, despite all pipes and joints being protected with asbestos-covering. Possibly this loss was due to the fact that the engines were not at full work, and did not take steam quickly enough along the pipes from the superheaters.

The Chairman (Mr. J. S. Dixon, Glasgow) said that he was interested in the packing of the joints of steam-pipes; and difficulties were encountered, even with pressures of 120 pounds per square inch.

Mr. C. C. Leach, replying to the discussion, said that there had been no alteration in the engine-packing; metallic packing was used for the piston-rods, except on the two winding-engines and donkey-engines, where ordinary soft packing was used. The cost of the superheater and steam-pipes was about £125 per boiler, but the cost depended partly on the arrangement of the steam-pipes. When there was a loss of 20·8 per cent., this was comparing the weight of duff-coal burned under 5 boilers with the amount of small coal burned under 4 boilers, before the super-

heaters were used; and this loss was due to using the very lowest grade of coal, and in boiling 5 instead of 4 boilers. The diagram (Fig. 3, Plate XVI.) shewed that the amount of superheat was erratic, and it was difficult to explain why one engine obtained superheat and the next engine had none. There had been no alteration as regards the expansion of steam, because all the engines, except the two winding-engines and donkey-engines, were worked expansively. The quality of the water was not good;* it contained a considerable quantity of sulphates (about 30 grains to the gallon), and it was treated with caustic-soda. He could not say whether there was any deposit in the inside of the superheater-pipes, as he had not seen them. The water did not go into the superheater, except what little might prime over, and steam did not leave any "furring." No packing was used for the steam-pipes, metal-to-metal joints were used with elastic cement between them, and therefore nothing could blow out or be burnt. The cement was plastered on to corrugated rings, and the joints were closed with nuts and bolts. Manganese-cement had been used, but it was no better than the ordinary cement employed at the colliery, and they continued using the latter The distances from the engines to the boilers was one of the difficulties of deciding if superheat would be of any advantage, and the engine nearest to the boilers showed the most superheat. None of the engines were compound, and the two vertical winding-engines and the pumping-engines were the only ones fitted with condensers. All the pipes were cast-iron, with planed joints, and there had been no breakdowns or fractures.

He had no information as to the result of working 3 boilers without superheating, as 3 boilers without superheating did not supply sufficient steam for the requirements of the colliery. The chimney was 73 feet high, and small for the work; but if the draught had been better, it is probable that higher results would have been obtained with the inferior coals. As to the relative economy of firing 2 boilers with small coal or 5 boilers with duff-coal, if the members fixed their own prices on the different kinds of coal they would see which cost the least.

He (Mr. Leach) would not have been able to indicate so many of the engines as he did, except for the able assistance afforded him by his engineer and mining-apprentices. The winding-engines were indicated during each revolution of a wind: the

* The total solids are 118 grains in 1 gallon of the water.

first revolution being taken of one wind, and the next revolution of the second, and so on for the top end of the cylinder, and similarly for the bottom end, and the time was taken with a racing watch, to 0·2 second.

There was a difficulty in getting the superheat to the engines, as it was speedily dissipated. It was perhaps more difficult at Seghill colliery, because most of the steam-pipes were too large in diameter, and presented a large cooling-surface, and the covering on the pipes, when the experiments were made, had been upon them for some years. Since then, new covering had been put on to the pipes. In the case of the engine receiving no superheat, of course it was being lost: it was difficult to prevent radiation; possibly the places of loss might be discovered by taking the temperatures in pockets on the steam-pipes. There was little alteration to the flues; these were rather narrow, and had been widened to take in the cradles and the superheaters.

The horsepower of the donkey-engines having been calculated (and not indicated), did not alter the results, because they were all at work before superheating was introduced, and altogether they did not amount to much. The question of expansion in no way altered the results, because all the engines were working exactly as they did before. The governors cut off the steam automatically and, naturally, did so earlier when there was less condensation in the cylinders (due to the superheating) and this was one part of the economy. High economy could not be obtained without much greater strains, but these did not increase the risks with proper machinery. Although the superheat might have disappeared before the steam reached the engine, the steam was drier, or, at any rate, had not had so much water condensed out of it, in the pipes, and therefore, even in these cases he (Mr. Leach) believed that there was a saving. Superheated steam was said to travel more quickly through pipes than saturated steam; but there seemed to be no tests to prove this or its extent, or how much smaller the steam-pipes ought to be. The use of superheated steam increased the speed of the winding, but he (Mr. Leach) had not sufficient records from which to compute a reliable average.

From the end of No. 3 pay, 1902, by which time the superheaters were worked properly, to the end of No. 25 pay, or 44 weeks, the coal burnt at the boilers day and night was

1·1233 per cent. of the drawings, and the lowest fortnightly average was 1·01 per cent.*

The CHAIRMAN (Mr. J. S. Dixon), in proposing a vote of thanks to Mr. C. C. Leach for his valuable paper, remarked that of the coal produced, about 1 per cent. was used during coal-work at Seghill colliery for steam-production. He thought that this was a very low figure, and he understood that 7½ per cent. was not considered unreasonable at many collieries.

Mr. W. C. BLACKETT (Durham), in seconding the vote of thanks, said that most of the members knew how much time and trouble had been taken by Mr. Leach to secure the most economical results at Seghill colliery. The paper was particularly interesting, as shewing the application of the principle of superheating steam at an old colliery. He would be rather ashamed of any colliery, under ordinary conditions, in Durham or Northumberland, at which the coal used both for engines and the supply of fire-coal to workmen reached 7½ per cent. of the production.

The vote of thanks was cordially approved.

Mr. J. B. SIMPSON read the following paper on "The Probability of Finding Workable Seams of Coal in the Carboniferous Limestone or Bernician Formation, beneath the Regular Coal-measures of Northumberland and Durham, with an Account of a recent Deep Boring made, in Chopwell Woods, below the Brockwell Seam":—

* The coal burnt at the boilers, day and night, in 1902, was 1·1179 per cent. of the drawings, and the lowest fortnightly average was 1·01 per cent.

THE PROBABILITY OF FINDING WORKABLE SEAMS OF COAL IN THE CARBONIFEROUS LIMESTONE OR BERNICIAN FORMATION, BENEATH THE REGULAR COAL-MEASURES OF NORTHUMBERLAND AND DURHAM, WITH AN ACCOUNT OF A RECENT DEEP BORING MADE, IN CHOPWELL WOODS, BELOW THE BROCKWELL SEAM.

By J. B. SIMPSON.

I. Introduction.

The Royal Coal Commission in 1871, in estimating the quantities of coal remaining unworked in the counties of Northumberland and Durham, dealt first with the coal in the upper or regular Coal-measures and then with the coal in the Lower Carboniferous rocks where they appear on the surface over a large area, chiefly in Northumberland. The Royal Commissioners seem to have disregarded the probability of coal being found in the Limestone-measures which underlie the regular Coal-measures of the Great Northern coal-field.

The writer, in his address to the Students of the Newcastle Branch of the Institution of Civil Engineers in 1896, referring to this point, said:—

> I may add that the Carboniferous or Mountain Limestone formation is not only found in the greater portion of Northumberland and a considerable portion of Durham, but it will naturally underlie the whole of the Northumberland and Durham coal-field. In fact, beneath our feet is another unexplored coal-field, and it would be a most interesting geological investigation, as well as of truly commercial and national importance, if workable seams at moderate depths could be proved. If this should be the case, and coal could be worked therefrom, it would be preferable to working from the same formation in the middle of Northumberland, as it would enable the present shafts and railways to be utilized and extended for its winning. Bore-holes, in the first instance, would throw a considerable light on the subject, and could, with no great expense, be made from the bottom of some of our shafts from what is usually termed the lowest workable seam, the "Brockwell." From this point, there are not supposed to be any seams of much importance until the Limestone formation is reached, and it is probable that coal of workable thickness may be met with within 1,000 feet below the Brockwell seam.

The object of this paper is to record what is known of the seams of coal, either by actual sinking or by bore-holes beneath the Brockwell seam, and to consider chiefly what prospects there are of workable seams being found, especially in the Mountain Limestone-formation under the regular Coal-measures.

From what is known of the occurrence of coal-seams under the area where the Lower Carboniferous formation comes to the surface, it is reasonable to suppose that those seams may continue under the regular coal-field; and, if so, their working would add considerably to the duration of our northern coal-field. From the former area, for many years, coal has been worked and is now being worked, in many places, at the outcrop and from shallow pits, but the output is not large and the quality of the coal in many places is inferior.

The geological map (Fig. 1, Plate XVII.), shews the area of the various formations in Northumberland and Durham, and it will be seen that the Carboniferous Limestone and Millstone Grit occupy extensive areas as compared with the regular Coal-measures, the relative areas being 1,500 square miles of the former and 700 square miles of the latter (including the coal under the Permian formation), the coal under the sea not being taken into consideration in either case.

II. Regular Coal-measures.

It is not necessary to refer to these more, than to say that their total thickness may be taken at 1,850 feet down to the base of the Brockwell seam, and in this depth there are about 26 seams of coal, varying from 12 inches to perhaps 7 or 8 feet in thickness, and amounting in the aggregate to about 80 feet.

III. Millstone Grit Series.

For present purposes, these measures include the strata from the Brockwell seam, including the Millstone Grit proper, to the top of the Lower Carboniferous Limestone. This depth is estimated by Mr. Westgarth Foster, and others, at about 600 feet, but few direct borings have been made from the Brockwell seam direct to the limestones. At Tudhoe colliery, it is recorded that a bore-hole met with limestone, 3½ feet thick, at a depth of 514 feet below the Brockwell seam. The recent borings made in Chopwell Woods (which we shall discuss further on) went direct to the limestone,

passing through several beds, and met with the first limestone at 481 feet below the Brockwell seam (probably this was the Fell Top limestone).

In this depth or zone, some 3 or 4 thin coal-seams varying from 6 inches to 2½ feet in thickness, and not more than 6 feet in all, have been found in various localities in the upper portion, but only two seams appear to be worked in any locality and that only at a few places in the two counties (Fig. 2, Plate XVIII.).

On Tyneside, the only place where a seam has been worked in this zone has been at Eltringham colliery, near Prudhoe. There, the Brockwell seam is found at a depth of 187 feet 8 inches; and the shaft was sunk further to the following seams:—

Coal-seams.	Thickness of Coal-seams. Ft. Ins.	Depth below the Brockwell Seam. Ft. Ins.
No. 1	1 6	11 9
No. 2	0 6	29 4
No. 3	1 3	45 9
No. 4, cannel	1 6	83 10

The lower seam was worked for a few years, its average thickness being: cannel, 2 feet; and coal, below, 1 foot. The working has been abandoned, owing to the cannel having been replaced by inferior coal.

At West Wylam colliery, a stone-drift has proved the following thin seams below the Brockwell seam:—

Coal-seams.	Thickness of Coal-seams. Ft. Ins.	Depth below the Brockwell Seam. Ft. Ins.
No. 1	0 6	22 3
No. 2	0 4	28 7
No. 3	1 0	30 7
No. 4	0 6	37 10
No. 5	0 7	54 11
No. 6	0 9	72 8
No. 7	0 9	141 5
No more coal was proved down to	...	210 2

At Hedley landsale colliery, 2 miles south-east from Stocksfield station, a boring proved the following seams below the Brockwell seam:—

Coal-seams.	Thickness of Coal-seams. Ft. Ins.	Depth below the Brockwell Seam. Ft. Ins.
No. 1	0 6	48 8
No. 2	0 6	57 1
No. 3	1 5	76 3
No. 4	0 6½	108 0
No more coal was proved down to	...	186 0

In Stella village, near Blaydon, a boring made there met wi the following seams:—

Coal-seams.	Thickness of Coal-seams. Ft. Ins.	Depth below the Brockwell Seam. Ft. Ins.
No. 1	0 4	16 9
No. 2	1 1	69 5
No. 3	1 6	85 11

At Chopwell colliery, a bore-hole was put down below tl Brockwell seam in 1795, but only thin seams were met with follows:—

Coal-seams.	Thickness of Coal-seams Ft. Ins	Depth below the Brockwell Seam. Ft. Ins
No. 1	1 1	45 9
No. 2	0 1	80 5
No. 3	0 1	94 4
No. 4	0 9	108 4
No. 5	0 2	148 7
No. 6	0 9	196 6
No. 7	0 3	223 6
No. 8	0 5	270 9

At Redheugh colliery, a boring below the Brockwell seam at a depth of 575 feet 4 inches, proved the following seams:—

Coal-seams.	Thickness of Coal-seams. Ft. Ins.	Depth below the Brockwell Seam. Ft. Ins.
No. 1	1 0	76 11
No. 2	0 9	87 2
No. 3	1 1	104 9
No. 4	0 8	125 2
No more coal was proved down to		158 3

A bore-hole from the Low Main seam at the B pit, Backwort colliery, proved the following seams, commencing at a depth c 649 feet 7 inches:—

Coal-seams.	Thickness of Coal seams Ft. Ins.	Depth below the Low Main Seam Ft. Ins
No. 1	2 6	275 7
No. 2	0 7	282 3
No. 3	1 11	358 2
No. 4	2 1	382 0
No. 5	2 9*	492 2
		Depth below the Brockwell Seam
No. 6	0 4	54 5
No. 7	1 6	69 4
No. 8	1 3	96 6
No more coal was proved down to		108 10

* This may be the Brockwell seam, from its position.

At Cramlington colliery, below the supposed Brockwell seam in the Betsy pit, the following seams have been proved by a bore-hole:—

Coal-seams.	Thickness of Coal-seams. Ft. Ins.	Depth below the Brockwell Seam. Ft. Ins.
No. 1, including 6 inches of band	1 11	33 11
No. 2	0 4	48 3
No. 3	0 10	88 7
No. 4	0 10	145 2
No. 5, including 16 inches of band	2 9	189 10
No. 6	0 10	317 11
No. 7	0 8	361 3
No more coal was proved to	...	412 7

These bore-holes, etc., seem to exhaust all that is known in the Tyneside district. It is possible that, in some localities, these seams may be of greater thickness, but up to the present time the information we have proves that in this zone the two seams of any moment do not exceed from 1 foot to 2 feet each.

In South Durham, the record is about the same. At Witton Park colliery, a boring made below the Brockwell found the following seams:—

Coal-seams.	Thickness of Coal-seams. Ft. Ins.	Depth below the Brockwell Seam Ft Ins.
No. 1	0 4	47 0
No. 2	0 6	73 1
No. 3	1 5	77 6
No. 4	0 4	124 2
No. 5	1 8	127 1
No. 6	1 8	177 4
No. 7	0 7	225 9
No more coal or limestone was proved down to	...	630 2

Another bore-hole in Beechburn royalty, not far distant, gave the following result:—

Coal-seams.	Thickness of Coal-seams. Ft. Ins.	Depth below the Brockwell Seam. Ft. Ins.
No. 1 or Victoria	2 0	70 3
No. 2 or Marshall Green	1 5	128 0

At Tudhoe colliery, a boring below the Brockwell seam found the following seams:—

Coal-seams.	Thickness of Coal-seams. Ft. Ins.	Depth below the Brockwell Seam. Ft. Ins.
No. 1	0 1	13 11
No. 2	0 6	140 6
No. 3	0 4	166 10
No. 4	0 4	227 4
No. 5	1 6	338 0
Limestone	3 6	514 0
No more coal or limestone was proved down to	...	609 0

The Victoria coal-seam has been found at Beechburn, Broo[illegible] park, Butterknowle, Coldknott, Etherley, Harperley Gate, Witt[illegible] Junction, and Woodifield; and it is (the writer believes) on[illegible] worked at one or two of these places, the height being not mo[illegible] than 2 feet.

The Marshall Green coal-seam is worked, in a limited way, [illegible] Marshall Green colliery.

There is, therefore, little to be expected from what is alrea[illegible] known in the Tynedale and south-western Durham districts of th[illegible] seams in the middle zone between the Brockwell seam and th[illegible] Limestone series; and we are not aware that the record is an[illegible] better in any other parts of the coal-field.

IV. Lower Carboniferous or Bernician Formation.

As already mentioned, the Bernician formation comes to th[illegible] surface over a large area of Northumberland and Durham. I[illegible] thickness is supposed to vary in different districts, and it co[illegible] sists of several beds of limestone, sandstone, shale and ironston[illegible] and several seams of coal. Probably, the least thickness of th[illegible] Limestone coal-bearing measures is 4,000 feet, below which follow[illegible] a great thickness of grits and shales down to the old Red Sand[illegible] stone formation.

Many papers have been written by members of the North [illegible] England Institute of Mining and Mechanical Engineers an[illegible] others concerning the geological features of this formation, an[illegible] the maps of the Geological Survey give the outcrops of the variou[illegible] limestones and beds of coal, in much detail; but there is sti[illegible] great difficulty in the correlation of these various beds, whic[illegible] can only be elucidated by the further mining operations [illegible] boring and sinking, and the careful tracing of the various bed[illegible] and their fossils from one district to another.

From Mr. Westgarth Forster's section of the strata of the west[illegible] ern district made many years ago, and a section prepared by[illegible]

Messrs. William and John Wilson and given by Mr. M. Walton Brown in a paper read by him before the members of the North of England Institute of Mining and Mechanical Engineers,* and from the knowledge which we now possess it would appear that there are two distinct zones whence coal has been worked and which for mining and geological purposes may appropriately be named:—(1) The Blenkinsopp, Acomb and Shilbottle series; and (2) the Plashetts and Scremerston series.

No. 1 Series.—No. 1 series may be taken as about 1,500 feet thick. The chief seams comprized in it are the Fell Top coal, about 2 feet thick; the Oakwood seam, 2 feet; the Blenkinsopp or Acomb seam, from 2 feet 8 inches to 4 feet; and the Shilbottle or Licker seam, the lowest of the series, about 2 feet 6 inches.

The following collieries, marked on the map (Fig. 1, Plate XVII.), are at present being worked in this zone and in the seams of the thicknesses mentioned:—

Names of Collieries	Names of Coal-seams.	Thickness of Coal-seams. Ft Ins. Ft. Ins.
Blenkinsopp	Acomb	3 2 to 3 11
Melkridge or Blackett	,,	1 10 ,, 2 2
Haltwhistle or South Tyne	,,	2 0 ,, 2 5
Thorngrafton	?	1 10 ,, 2 0
Fourstones	Acomb	2 4 ,, 4 0
Fallowfield	,,	3 0 ,, 4 6
Acomb or Tynedale	,,	—
Whetstone, Killhope	Fell Top	2 6
Coldcleugh	Acomb	2 4
Halton	,,	1 5
Whittington	,,	1 8
Kirkheaton	,,	2 8
Sooty Row	?	2 4
Longframlington	Shilbottle	2 6
Longhorsley	,,	2 6
Netherwitton	,,	2 8
Newton-on-the-Moor	,,	2 10
Shilbottle	,,	2 0
Wallshield	,,	2 0

There has been a great development of coal-working in the Haltwhistle district, chiefly at Blackett colliery, and this district, in consequence of the favourable nature of the coal, will in future years be further developed.

* *Trans. N.E. Inst.*, 1887, vol. xxxvii., page 16.

No borings have been made below the Blenkinsopp seam, to prove the whole of the upper zone, or the existence of the seams in the lower zone. However, the time will soon come, when explorations will be attempted.

No. 2 Series.– No. 2 series may be taken as probably 1,800 feet thick, but none of the seams in it have been proved or sunk to in the area where the seams in the upper zone are worked.

There are several coal-seams, the chief seams of the Scremerston district being named as follows: The Eelwell coal, the Greenses or Beadnell seam, the Muckle Howgate seam, the Little Howgate seam, the Fawcett coal, the Scremerston Main coal, the Hardy coal, the Cancer seam, the Three-quarter coal, the Cooper-eye coal, and the Wester coal-seam. These seams vary in quality, and the thicknesses range from 2 to 4 feet, including bands of shale.

In the Plashetts district, also in this series, the chief seams are the Hareshaw Head, Haining-rigg, Furnace, Caritet [illegible], Plashetts, Shilburnheugh and Lewis Burn coal-seams.*

The following collieries are working one or more of these seams:

Names of Collieries.	Thickness of Coal seams. Ft.	Ins
Fourlaws	2	0
Hareshaw Head	2	8
Gunnerton	2	2
Shilburnheugh	2	0
Plashetts	4	0
Brownrigg	2	6
Elsdon	2	0
Chatton	2	0
Licker	2	0
Scremerston	3	6
Felkington	2	0

The chief collieries working coal from this zone are at Plashetts and Scremerston. The seam worked at Plashetts colliery has been assumed to lie in about the same horizon as the Scremerston Main seam. Its thickness is about 4½ feet, and it is estimated to extend over a large area. At Scremerston colliery, although the district

* Since reading this paper, the author has been informed that several bore-holes have recently been made in the Greenhead and Walltown district, and coal-seams have been found, one, 3 feet thick, evidently belonging to the lower zone of No. 2 series. This augurs well for other seams of the Scremerston and Plashetts series being found in future explorations.

abounds in many seams of coal and is of large extent, there is at present only one seam being worked, namely, the Cooper-eye seam.

The writer has estimated the total output of the 36 collieries working Limestone coals at 478,000 tons, the greater portion, about 66 per cent., being obtained from the first series of seams.

Coal has been worked in many other places in the Carboniferous Limestone formation, and it may be interesting to know that working took place in some localities at an early period. It is recorded that coal was worked at Middleholm, near Mitford, in 1250; at Buteland, near Bellingham, in 1296; in 1418, at Shoresworth, near Berwick; in 1440, the monks of Holy Island expended £2 6s. 8d. in sinking a pit at Howburne; in 1455, at North Sunderland; in 1473, further expense was incurred by the Earl of Northumberland at Bilton, near Alnmouth, in connection with the sinking of a new coal-pit; in 1510, at Tweedmouth, Scremerston and Ford; and in 1532, 1567 and 1663, coal was being worked at Shilbottle. In 1547, the lord of Hexham manor received rent for a coal-mine at Fallowfield.*

Cumberland and Yorkshire.—Coal is being worked in the Bernician formation in north Yorkshire and in east Cumberland, but as this hardly falls within the scope of the present paper and as the writer does not possess much knowledge of these districts, he has omitted them from present consideration.

Resources.—There is no doubt that this Bernician formation is capable of further development; and, when the coal from the Upper Coal-measures becomes more scarce and more costly to work, the Bernician coal will come more into play, especially if railways be further extended and the cost of railway-carriage be decreased.

The quality of the coal in some of the districts has not been found equal to that from the true Coal-measures, but it must be borne in mind that the coal in all instances is worked from shallow depths. Some of the collieries produce extremely good coal: for instance, Shilbottle has a first-class house-coal while Blenkinsopp, Blackett, and others yield a good manufacturing and coking coal.

* "Extracts from the Account Rolls of the Abbey of Durham," in three volumes, *The Publications of the Surtees Society*, vols. xcix, c., and ciii.

Mr. M. Walton Brown, in a paper read by him before the North of England Institute of Mining and Mechanical Engineers,* in referring to this formation, mentions that the Royal Coal Commission in 1871 estimated the quantity of available coal at 665,000,000 tons, and he states that "the available areas and the thickness of seams have been under-estimated. Thus, in the Scremerston district, the seams appear to be from 54 to 73 feet in aggregate thickness. This development is not found in other parts of the Mountain Limestone, as in the more southern districts not more than four seams are found, which are only of workable thickness in small areas. In an area of 1,200 square miles in the northern part of this coal-field (omitting the portions covered by the Upper Coal-measures) it may be assumed that there is at least 10 feet in thickness of workable coal. The contents of 1 square mile of this thickness will be 9,600,000 tons and of 1,200 square miles will consequently be 11,520,000,000 tons. After an ample allowance for dykes and other interruptions there will probably remain an available supply of 8,000,000,000 tons." There can be no doubt that Mr. Walton Brown is correct in saying that the figures of the Royal Commission were under-estimated, but they will doubtless be revised by the Royal Commission recently appointed, in the light of our present knowledge of the district.

Covered areas.—We now come to consider the probability of coal of workable thickness being found under the area occupied by the Millstone Grit and under that of the regular Coal-measures.

There have been few borings made directly from the regular Coal-measures to the Carboniferous Limestone. At Tudhoe colliery, a boring was made some years ago, and at a depth of 514 feet below the Brockwell seam a bed of limestone, 3½ feet thick, was proved; the boring was extended to a further distance of 95 feet, but neither coal nor limestone was found.

Chopwell Bore-hole.—By the enterprise of Messrs. Priestman & Company, of the Garesfield Coal Company, and with the assistance of H.M. Commissioners of Woods and Forests, some further light has been thrown on the strata lying below the Brockwell seam, by a deep bore-hole which was put down in 1897 in Chopwell Woods, near Lintz Green and the river Derwent.† The

* *Trans. N.E. Inst.*, 1887, vol. xxxvii., page 10.

† Longitude, 1° 46′ 35″ west; and latitude, 54° 55′ 40″ north.

particulars of this section are set forth in Appendix I. and in a section (Fig. 3 Plate XIX.). This bore-hole commenced at a position in the strata assumed to be 166 feet below the Brockwell seam, and passed through the following beds of coal: —

Coal-seams.	Thickness of Coal-seams. Ft. Ins.	Depth from Surface. Ft. Ins.	Depth below the Brockwell Seam. Ft. Ins.
No. 1	0 4	19 0	185 0
No. 2	0 1	74 1	240 1
No. 3	0 1	680 11	846 11
No. 4	0 4	1,054 1	1,220 1
No. 5	0 2	1,186 3	1,352 3
No more coal was proved down to ...		1,318 0	1,484 0

The bore-hole passed through the following limestones: —

Limestones.	Thickness of Limestones. Ft. Ins.	Depth from Surface. Ft. Ins.	Depth below the Brockwell Seam. Ft. Ins.
No. 1	1 11	315 3	481 3
No. 2	6 1	416 9	582 9
No. 3	18 10	491 9	657 9
No. 4	2 8	557 10	723 10
No. 5	15 8	634 11	800 11
No. 6	7 2	844 8	1,010 8
No. 7 or A	12 2	1,010 6	1,176 6
No. 8	6 10	1,084 5	1,250 5
No. 9 or B	50 2	1,148 1	1,314 1
No. 10 or C	20 2	1,303 5	1,469 5

It was assumed, from all the information that we had connecting the Upper Coal-measures with the Carboniferous Limestone formation, that the latter might be met with at about 600 feet below the Brockwell seam. This bore-hole met the first bed, probably the Fell Top Limestone, at a depth of 481 feet; it was however, only 1 foot 11 inches thick.

Then, as to coal, we assumed that the Blenkinsopp or Acomb seam might be found at a depth of about 1,000 feet. The first coal in the Carboniferous Limestone formation was met with at a depth of 847 feet below the Brockwell seam, its thickness being only 1 inch. At 1,220 feet, a 4 inches seam was passed through, and at 1,314 feet, a limestone, 50 feet thick, was reached: it may be the Great Limestone. Comparing the position of the coal-seams and limestones met with in this section, and that of Tynedale, it would appear that the letters A, B and C are the relative positions of the limestones in each section; and, it may

almost be concluded that the coal, 4 inches thick, is the representative of the Acomb coal-seam.

At 1,352 feet, another seam, 2 inches thick, was reached, and this might represent the Shilbottle seam of the northern district, but it is difficult to make a definite correlation on such slender data.

The bore-hole has been disappointing, especially as it attained a depth of 1,484 feet below the Brockwell seam, and no coal was found of workable thickness, but only five seams of 4 inches, 1 inch, 1 inch, 4 inches and 2 inches respectively. Of course one bore-hole, only 4 inches in diameter, is not sufficient to condemn the whole area as barren of workable coal. It is, however, so far satisfactory that coal and limestone have been found in about the stratigraphical positions in which they were expected.

From a comparison of the sections that the writer has compiled, it will appear that from the position of the limestones in the bore-holes and from their assumed positions in the western and northern districts, it is almost impossible to correlate them until much more information is obtained.

It may, however, be concluded that the Great Limestone, B, in the Tynedale section of Mr. Westgarth Forster occurs at 979 feet below the Brockwell seam and is 63 feet thick; in the Chopwell bore-hole it would appear to lie at 1,314 feet below and to be 50 feet thick; and at Scremerston, it may be assumed to occur at 1,036 feet and to be 28 feet thick.

It seems most unlikely that workable seams of coal, which are found close to the outcrop of the Millstone Grit and extending over so many miles, should suddenly come to an end, or continue only a few inches in thickness under the Millstone Grit and the superimposed regular Coal-measures. We have also the fact that in Midlothian, the Mountain Limestone formation contains many workable seams, which are sunk to through the regular Coal-measures and Millstone Grit series lying above them. Perhaps it may be that the Chopwell bore-hole did not go deep enough, as there is a thickening of the strata going eastward, and this might throw the coal-seams deeper; or it is possible that the bore-hole might go down on a local "nip," or that the thickness was not correctly ascertained. There is no doubt that the seams in the Mountain Limestone do vary in thickness, and make it difficult to trace the seams over a large area. For instance, the Acomb seam

as found near Hexham is 4 feet 6 inches thick, while in the Allenheads district it is represented by only a few inches of coal.

The writer may mention that near Stockton several bore-holes were put down, and in one or two instances it is supposed that after passing through the Permian formation (the true Coal-measures being absent) the Mountain Limestone formation was met with and bored into. In one of the bore-holes, the limestone was reached at a depth of 1,479 feet, and coal, 2 feet thick, was met at a depth of 1,952 feet.* This is, of course, a thin seam, but it is so far satisfactory, as it favours the idea that coal-seams may be continuous from the northern district under the regular Coal-measures, into the Stockton district.

The Chopwell bore-hole, above mentioned, has not at any rate explored the whole depth of the Carboniferous Limestone-measures and has probably not gone through the upper zone. Below the depth reached, there should follow all the strata down to the Old Red Sandstone, and therein the several seams of coal and beds of limestone of the Scremerston and Plashetts districts should be found, and this might reach a total depth of 4,000 feet below the Brockwell seam. But if some of the seams should not be reached within a depth of 2,000 feet or 3,000 feet below the Brockwell seam, they would in the deeper parts of our coal-field be quite beyond a workable depth, according to our present commercial ideas.

The writer is still of opinion, however, that further explorations may well prove large areas of coal of workable thickness at accessible depths, and as coal becomes more scarce they will be proved and worked. The question, however, can only be settled definitely by further borings and sinkings being made in the different districts; and no doubt, in time, these will be carried out.

In considering our national supplies of coal, the subject becomes an important one, especially in the future industrial interest of Northumberland and Durham, and the writer has no doubt that the present Royal Commissioners will endeavour to obtain all the available information so as to enable them to offer an opinion on the probabilities of an additional supply from the areas which have been brought under consideration in this paper,

* *Trans. Inst. M.E.*, 1890, vol. i., page 362

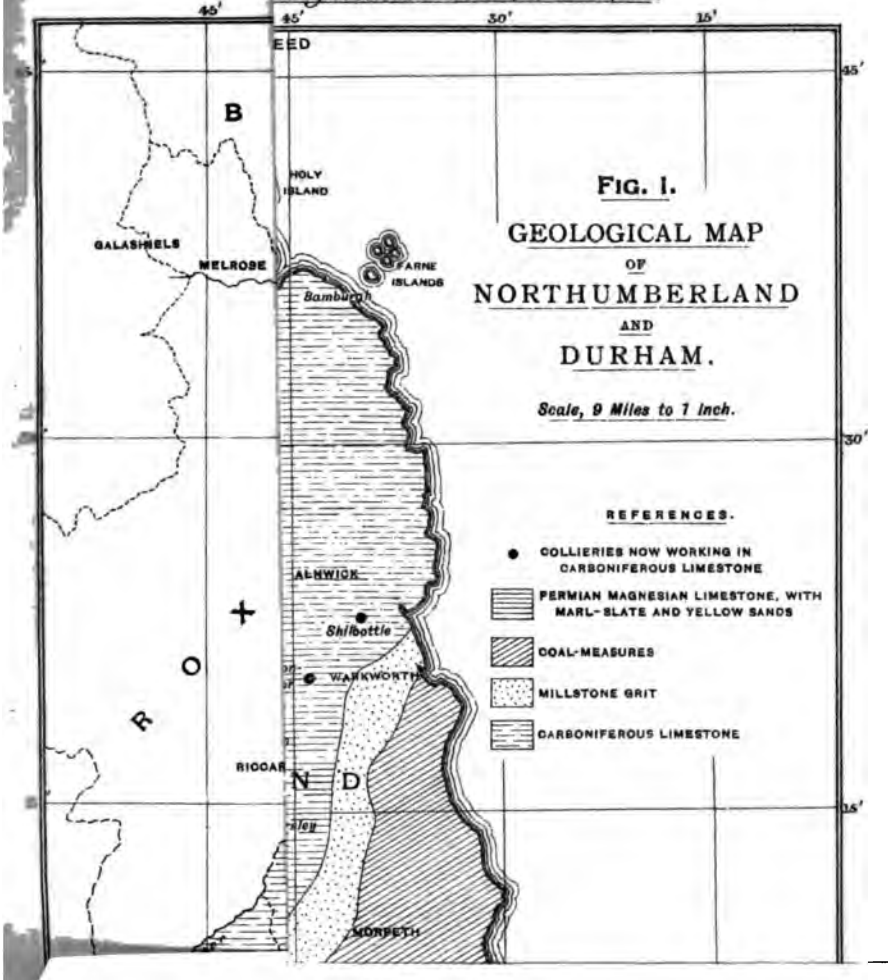
and which did not enter into the estimate of the former Royal Coal Commission of 1871.

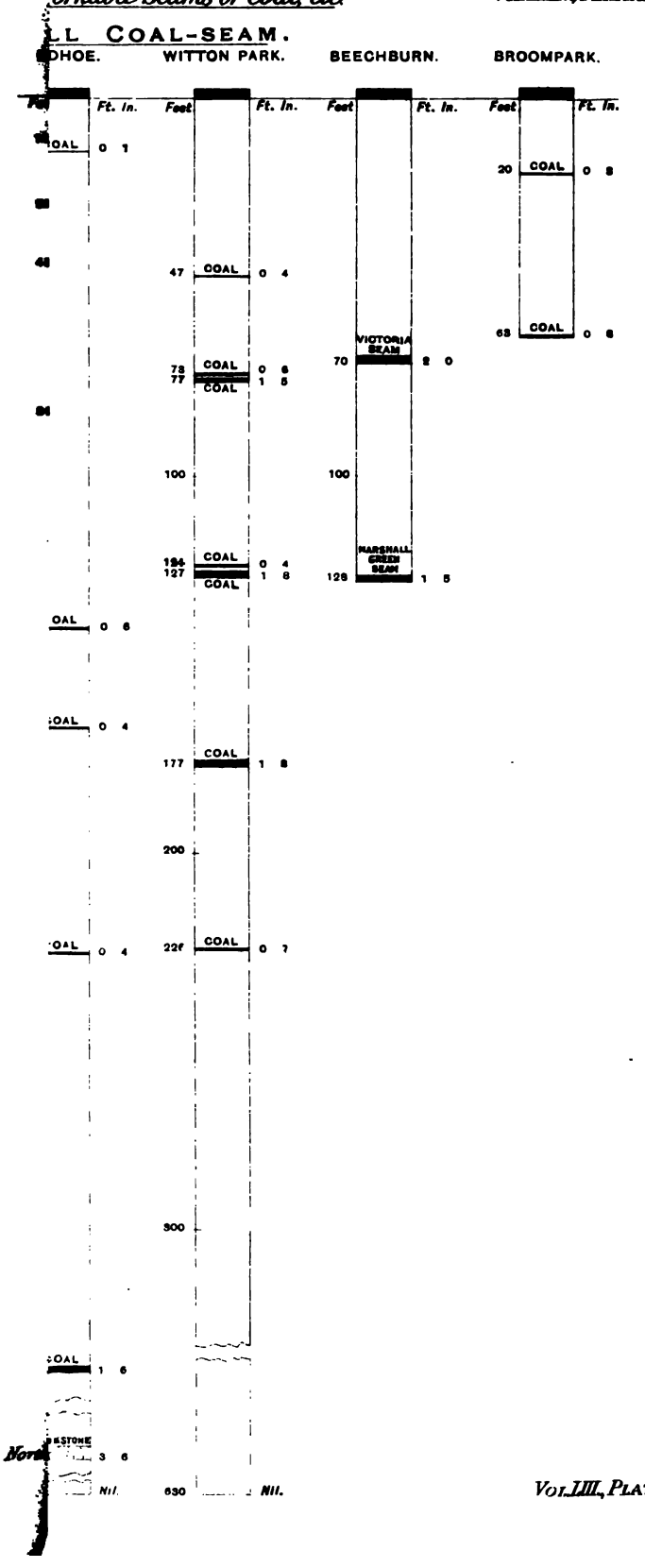
In conclusion, the writer must apologize for bringing forward a paper of a somewhat speculative character, but at the same time he hopes that the attempted record of our present practical knowledge of the coal-seams in the formations beneath the Upper Coal-measures may be of some use in the future elucidation of the scientific and economic geology of the two counties.

APPENDIX I.—Section of Strata in a Bore-hole near the River Derwent in South-eastern Corner of Boundary and 136 Chains West of Lintz Ford Mills, Chopwell Woods, at a position in the Strata supposed to be 166 Feet below the Brockwell Seam.

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1	Clay, sand and soil	4	6	4	6
2	Boulder-clay	12	0	16	6
3	Broken freestone	0	8	17	2
4	Very dark grey shale	1	6	18	8
5	**COAL**, very coarse	0	4	19	0
6	Dark grey shale	2	0	21	0
7	Grey sandstone	18	0	39	0
8	Grey sandstone and thin shale-partings	8	6	47	6
9	Very dark grey shale	0	10	48	4
10	Soft grey shale, with post-girdles	4	6	52	10
11	Dark grey shale	3	8	56	6
12	Strong grey post	2	1	58	7
13	Soft dark grey shale	15	5	74	0
14	**COAL**	0	1	74	1
15	Seggar	2	6	76	7
16	Dark grey shale	4	9	81	4
17	Strong grey post	11	0	92	4
18	Dark grey shale	3	10	96	2
19	Strong grey post	6	2	102	4
20	Dark grey shale	11	0	113	4
21	Strong grey post, laminated	61	7	174	11
22	Dark grey shale	21	6	196	5
23	Very strong grey post	16	0	212	5
24	Seggar	0	9	213	2
25	Soft dark grey shale	1	6	214	8
26	Light grey post	10	0	224	8
27	Dark grey shale	7	0	231	8
28	Very strong light grey post	5	2	236	10
29	Dark grey shale	18	2	255	0
30	Light grey post and *coal*-threads	2	0	257	0
31	Seggar	2	4	259	4
32	Dark shale	4	1	263	5
33	Grey post	1	0	264	5
34	Dark grey shale	6	2	270	7
35	Grey shale, with post-girdles	3	9	274	4
36	Grey post, with metal-partings	24	6	298	10
37	Dark grey shale	14	6	313	4
38	*Limestone*, grey	1	11	315	3
39	Coarse grey seggar	2	2	317	5
40	Grey post, with shale-partings	8	1	325	6
41	Grey shale	8	0	333	6
42	Coarse seggar	1	0	334	6
43	Grey post, with threads of shale	12	7	347	1
44	Grey shale	5	1	352	2
45	Dark grey post	6	2	358	4
46	Seggar, coarse	2	1	360	5
47	Grey post, with shale-partings	33	0	393	5
48	Dark grey shale, with post-girdles	10	2	403	7
49	Hard grey post	7	1	410	8
50	Dark shale, with *limestone* and shells	6	1	416	9
51	Grey post, very coarse & strong	32	11	449	8
52	Grey shale, with post-girdles	23	3	472	11
53	*Limestone*, and occasional shaly partings	18	10	491	9
54	Grey post	12	1	503	10

ding Workable Seams of Coal," etc.

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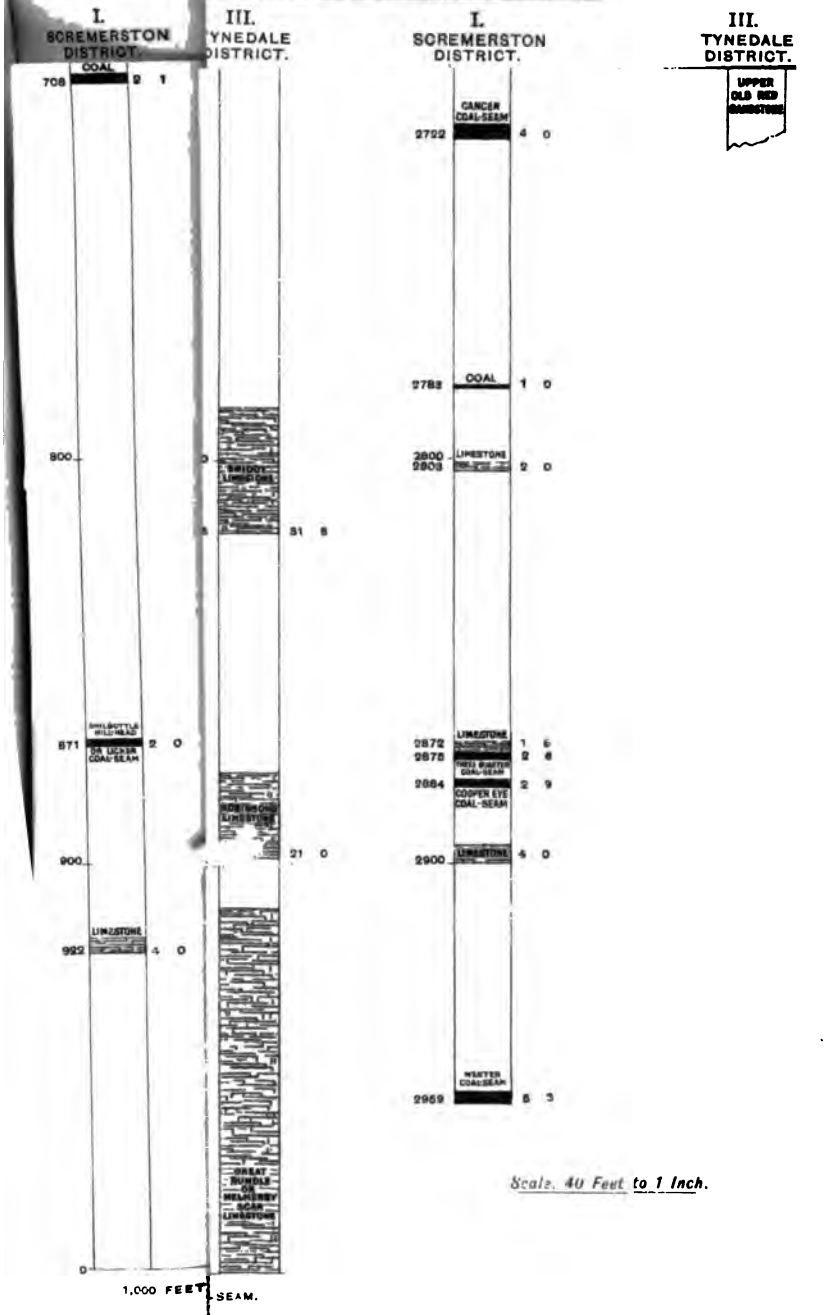
finding Workable Seams of Coal," etc.

BROCKWELL COAL-SEAM.



Scale, 40 Feet to 1 Inch.

SEAM.

The North of E

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
55	Dark grey shale ...	6	3	510	1
56	Grey post ...	12	5	522	6
57	Grey shale	2	8	525	2
58	Dark grey post ...	1	4	526	6
59	Dark grey shale, with ironstone-bands	21	0	547	6
60	Grey post, with much silica and shale-partings	7	8	555	2
61	*Limestone*, grey ...	2	8	557	10
62	Coarse grey post	50	11	608	9
63	Grey post and shaly partings, with threads of *coal* ..	5	5	614	2
64	Dark grey shale	5	1	619	3
65	*Limestone*, grey ..	15	8	634	11
66	Grey post, with shaly partings	19	3	654	2
67	Grey slate, with post-girdles ..	10	11	665	1
68	Strong grey post ...	15	9	680	10
69	**COAL**, coarse	0	1	680	11
70	Dark grey post, with shaly partings	23	6	704	5
71	Dark grey shale ...	13	4	717	9
72	Strong grey post, with a little *limestone*	1	4	719	1
73	Strong grey post	29	6	748	7
74	Grey post, with shaly partings	5	8	754	3
75	Strong grey post	15	10	770	1
76	Strong grey post, with shaly partings	48	2	818	3
77	Grey shale and ironstone-balls	19	3	837	6
78	*Limestone*, blue, with shells ...	7	2	844	8
79	Grey post ...	13	11	858	7
80	Grey post and shale	8	4	866	11
81	Dark grey shale ...	3	5	870	4
82	Grey post and shaly partings	5	2	875	6
83	Soft dark grey shale	1	7	877	1
84	Strong grey post	39	3	916	4
85	Grey shale ...	8	10	925	2
86	Grey post and shaly partings	25	6	950	8
87	Grey shale ..	4	6	955	2
88	Grey post ..	2	0	957	2
89	Dark grey shale	12	6	969	8
90	Grey post, with shaly partings	9	9	979	5
91	Dark grey shale, with iron-pyrites	18	11	998	4
92	*Limestone*, blue, **A**	12	2	1,010	6
93	Grey post, with shaly partings	5	5	1,015	11
94	Grey shale, with post-girdles ...	17	8	1,033	7
95	Hard grey post and shaly partings	20	2	1,053	9
96	**COAL**	0	4	1,054	1
97	Grey post ...	1	3	1,055	4
98	Grey shale with pyrites ...	22	3	1,077	7
99	*Limestone*, blue	6	10	1,084	5
100	Dark grey shale	13	6	1,097	11
101	*Limestone*, blue, **B**	50	2	1,148	1
102	Dark grey post	1	4	1,149	5
103	Grey shale and pyrites ...	1	1	1,150	6
104	Gannister ...	1	0	1,151	6
105	Grey post, with silica	34	7	1,186	1
106	**COAL**, coarse ...	0	2	1,186	3
107	Dark grey post ...	2	7	1,188	10
108	Very coarse strong post, with thin *coal*-threads ..	54	3	1,243	1
109	Dark grey shale	40	2	1,283	3
110	*Limestone*, blue, **C**	20	2	1,303	5
111	Grey post ...	14	7	1,318	0

The PRESIDENT (Sir Lindsay Wood, Bart.) said that the members were much indebted to Mr. J. B. Simpson for having brought this important matter before them. It was the more important at the present time, as Mr. Simpson pointed to another source of coal-supply, which, in the public mind, was formerly not in existence.

Prof. R. A. S. Redmayne (The University, Birmingham) said that Mr. Simpson's paper was of the greatest interest to mining-engineers, in view of the fact that the Coal Commission was at present engaged in enquiring into the question of the coal resources of the kingdom. He had just returned from the United States of America, and had been interested by the extraordinary depths from which minerals were drawn in that country. Mr. Simpson had mentioned that an extraordinary depth would be 4,000 feet, but at the Tamarack mine they were drawing from a depth of 5,100 feet, and at Trimountain, which was at present 900 feet deep, a winding-engine was in process of being erected to draw from a maximum depth of 6,000 feet. Again, at the Calumet and Hecla mine, the depth of the Red Jacket (vertical) shaft was 4,800 feet. With regard to the Chopwell Woods boring, was it not quite probable that there might be a thickening of the Bernician formation in that district? They knew of such thickenings in other parts of the country, and that formation might very probably thicken as much as 3,000 feet.

Mr. David Burns (Carlisle) said that he might mention one little scrap of comfort in connection with Mr. Simpson's paper, and that was that the beds from about the third or fourth limestone shown in the section illustrating his paper, thickened very much as they went downward. South of the South Tyne river, if a particular bed of limestone were selected and followed in the country to the north of that river, it would be found to break up into several more or less impure limestones, with calcareous sandstones and shales between, giving an aggregate thickness much in excess of the limestone, where first seen to the south, so that if a sinking were made in the county of Durham the Scremerston coal-seams, if present at all, would be found much nearer to the surface than would appear to be the case from the sections measured at the outcrops of the measures. At any rate, this will prove to be so if the beds vary in the east of Northumberland as in the west.

Mr. A. L. Steavenson (Durham) said there was no one in a position to dispute or criticize the paper just read by Mr. Simpson, that gentleman having made the subject peculiarly his own. The paper was a most valuable contribution to the *Transactions*, and would remain for future years a mine of information, not

only about the Chopwell bore-hole, but about all that is known in the district on the subject. Mr. Simpson had said that the question as to these lower seams could only be settled definitely by further borings and sinkings being made in the different districts. This was very likely true, but at the same time he (Mr. Steavenson) would be inclined to look at the outcrops and see if anything could be found out respecting them. The depth of 4,000 feet mentioned by Mr. Simpson in his paper had been arrived at by an investigation of these outcrops; and it would also be useful if he made some reference to the rocks and coal-seams in the neighbourhood of Barnard Castle and Wensleydale.

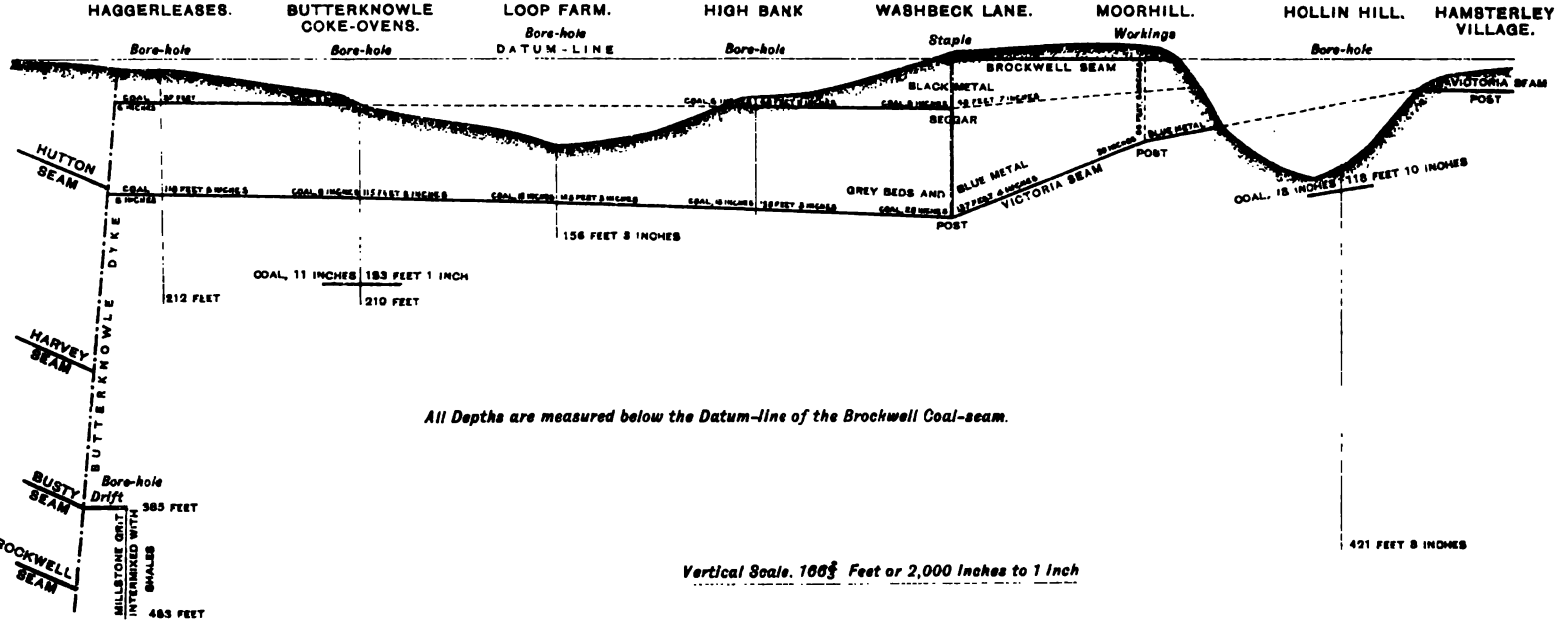
Mr. John Morison (Cramlington) said that he had listened to Mr. Simpson's paper with the greatest interest, and having had considerable experience in connection with the Mountain Limestone series in Scotland, he agreed with Mr. Simpson's hopeful view that workable coal-seams would be found under the regular Coal-measures in Northumberland and Durham. One single bore-hole, as Mr. Simpson had said, could not be taken as a true guide as to whether workable seams would be found. If the seam was missed in the Chopwell bore-hole, there was a large area still to be investigated, and he thought that there was every probability of workable seams being found at workable depths in south-east Northumberland and possibly in Durham. From the indications, however, he should say that south-east Northumberland would seem a more hopeful field than Durham, because these lower seams had been proved over a large area of outcrops, and seemed to be fairly persistent northward from the river Tyne.

Mr. John Nevin (Mirfield) said that, on comparing the section of the Chopwell bore-hole with Mr. Westgarth Forster's section of the measures, which has been proved to be very correct in the Alston and Allendale districts, with which he (Mr. Nevin) had some acquaintance, he noticed that while Mr. Forster gives the thickness from the Brockwell seam to the first or Fell Top limestone as 509 feet, the Chopwell bore-hole shows 481 feet to the first limestone. If, however, he took the Chopwell limestone, 50 feet thick, the bottom of which is 1,314 feet below the Brockwell seam, as answering to the Great limestone, the bottom of which Mr. Westgarth Foster gives as 979 feet below the Brockwell seam, there is a thickening of the measures of 335 feet or

34 per cent. If this be so, the 4 inches of coal, at a depth of 1,220 feet below the Brockwell seam, would represent the seams between the Great and Little limestones, now worked near Alston and in West Allendale; and the limestone at a depth of 1,176 feet would represent the Little limestone—several limestones having set in between this and the Fell Top limestone. He (Mr. Nevin) suggested that this was the case, and he was afraid that there was not much chance of finding workable coal-seams at a reasonable depth in this neighbourhood. He considered that a bore-hole, say, at Broomhill or Amble, would be more likely to find workable seams in the Limestone-measures.

Mr. J. S. Robson (Butterknowle colliery) wrote that he could not give any reliable information relative to the coal-seams lying below the Brockwell seam, except with regard to the strata lying immediately below the above-named seam in the Butterknowle district. The sections (Plate XX.) only include sections of bore-holes, etc., in which the seams can be correlated, and exclude those others in which the stratigraphical position of the coal-seams does not appear to have been correctly obtained. So far as workable coal is concerned, the Victoria seam is the only one below the Brockwell, found to be of any present value, in this district. This seam is now being explored at Moor Hill, at a depth of 68½ feet below the Brockwell seam. The coal averages 2 feet 6 inches in thickness with one or two irregular bands, ½ to 1 inch thick. At Washbeck Lane, about 4,200 feet south-west of the workings at Moor Hill, a staple has been sunk to the Victoria seam, 137 feet 4 inches below the Brockwell seam, almost exactly twice the depth at Moor Hill. A seam, 11 to 13 inches thick, has been found about 80 feet below the Victoria seam at Hollinhill and the Butterknowle coke-ovens; and explorations to a further depth of about 300 feet, have proved Millstone Grit, with shales, but no coal has been found.

Mr. J. B. Atkinson (H.M. Inspector of Mines, Newcastle-upon-Tyne) wrote that in the south-western part of Northumberland, the south-eastern and southern parts of Cumberland, in the west of Durham, in Yorkshire, and in Lancashire where the Bernician beds come to the surface and are capable of direct observation without the aid of mining operations, the coal-seams found in this series in the northern parts of Northumberland and Cumber-



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Andrew Reid & Comp.y Ltd. Newcastle on Tyne.

land do not exist, or are represented by only a few inches of coal, and this barren condition prevails farther south; while going into Scotland, the Bernician coal-seams increase in thickness. But in south-western Northumberland, in western Durham, in south-eastern and southern Cumberland, in Yorkshire, and in Lancashire, the information obtained by surface-examination is confirmed by the exploration of the beds in mining for ores of lead, zinc and iron. The presumption is therefore that the farther south one goes the less probability there is of finding workable coal-seams in the Bernician beds, and it appears to him (Mr. Atkinson) that the results obtained in the Chopwell bore-hole might have been anticipated.

There seems to be no reason to believe that the Bernician beds may not be productive of coal-seams under the Upper Coal series; this is practically proved to be the case at one or two points in Northumberland and Cumberland, and it is undoubtedly the case in Scotland, although there it has not been proved to the extent that Mr. Simpson supposes, as will be mentioned later. What is the course of the line marking the southern boundary of the productive Bernician beds, he (Mr. Atkinson) could not state, but he thinks that the Chopwell bore-hole may lie to the south of this line.

It appears more probable that workable coal-seams may be found in the Bernician beds underlying the Upper Coal-seams in Northumberland than in Durham, and the farther north one goes in Northumberland the greater is the probability of a favourable boring. Bore-holes through the Upper Coal series, lying north of the Blyth or Wansbeck rivers, would be very likely to pass through workable coal-seams in the Bernician beds, and it is here that the first successful results must be looked for, rather than in the county of Durham.

Mr. Simpson's statement that in Midlothian "the Mountain Limestone formation contains many workable seams" is correct, but he is not quite accurate when he continues "which are sunk to through the regular Coal-measures and Millstone Grit series lying above them." There is only one example of the kind in Midlothian, the Newbattle Victoria pit, which passes through the lower part of the Millstone Grit and is sunk nearly 1,800 feet to one of the lowest seams in the Mountain Limestone. The writer is only aware of one other example of the kind in Scotland: the

Fence pits, near Lesmahagow, in Lanarkshire, passed through the Virtuewell, Kiltongue and Drumgray seams lying in the lower part of the Upper Coal-seams, through the Millstone Grit and down to the Lesmahagow cannel coal-seam in the Mountain Limestone. There can, however, be no reasonable doubt that, in Scotland, large areas of workable coal-seams in the Mountain Limestone underlie the Upper Coal-seams.

Mr. Simpson gives the total estimated production of coal from Mountain Limestone in the North of England as 478,000 tons; and the output in 1887 was:—Northumberland, 332,961 tons; and Cumberland, 50,913 tons.* The comparative production of coal from the various formations in Scotland, in 1892, were:—Oolite, 4,622 tons; Coal-measures, 21,307,081 tons; Millstone Grit, 3,950 tons; Carboniferous Limestone, 5,876,020 tons; Calciferous Sandstone, 250 tons; a total of 27,191,923 tons.†

Mr. M. F. Holliday (Littleburn Colliery) wrote that, at Broompark colliery, the following coal-seams had been found below the Brockwell seam, lying at a depth of 562 feet 4 inches:—

Coal-seams.	Thickness of Coal-seams. Ft.	Ins.	Depth below the Brockwell Seam. Ft.	Ins
No. 1	0	3 ...	20	6
Victoria	0	8 ...	63	0
No more coal proved down to ...	...	...	66	0

He thought that Mr. Simpson was correct in his conclusion—that workable seams will be found below the Brockwell seam. The matter is of vital importance, and all lessors and lessees of mines in Northumberland and Durham should combine, and solve the question by having large bore-holes put down in different parts of the coal-field.

Mr. J. C. B. Hendy (Etherley) wrote that, since the bore-hole was put down at Witton Park in 1834 by Sir William Chaytor, several attempts have been made in the western portion of the Bishop Auckland district to prove and work the coal-seams lying below the Brockwell seam and in the Millstone Grit, but the results so far only appear to shew that these coal-seams are very variable in section and quality.

* "Mining and Quarrying," by Mr. J. B. Atkinson, *British Association, Newcastle-upon-Tyne Meeting, 1889: Official Handbook to the Industries*, page 37.

† "The Mining-fields of Scotland," by Mr. J. B. Atkinson, *Transactions of the Mining Institute of Scotland*, 1893, vol. xiv., page 219.

The Victoria seam has for some time been successfully worked at the Woodifield colliery, near Crook; but taking a line running about south 11 degrees east from that colliery to Witton Park, a distance of about 3 miles, at Woodifield it has a thickness of about 2 feet 6 inches; at Low Beechburn of 1 foot 8 inches; near Witton Junction, it has increased again to 2 feet 6 inches; and at Witton Park, it has again decreased to only 1 foot of coal. On another line, running about south 28 degrees west, from Woodifield to Butterknowle, a distance of nearly 7 miles, the Victoria coal-seam has been proved of the following sections:—Woodifield, 2 feet 6 inches; a little to the west of Hargill Hill, 1 foot 10 inches; near Stonechester, it has been proved to be a little over 2 feet; and at Butterknowle it is about 2 feet 4 inches. It seems probable, therefore, on the greater portion of the latter line, that the Victoria seam may be found of a workable thickness, excepting, of course, where it is denuded in that part which crosses the valley of the river Wear.

The Witton Park bore-hole proved another seam, 2 feet thick, about 48 feet below the Victoria seam, with a band of fire-clay, 1 foot 3 inches thick. This seam has been worked at Marshall Green colliery, but he (Mr. Hendy) was not aware that it had been successfully worked elsewhere in the district.

Another seam, 6 inches thick, has been found a little to the west of Witton-le-Wear, lying at a horizon about 150 feet below the Victoria seam; and this seam may be correlated with the lowest seam mentioned in the Witton Park section. So far as he (Mr. Hendy) was aware no workable coal-seam had been proved in the Millstone Grit series of this district below the last-mentioned seam.

Between Frosterley and Stanhope, a seam of coal, about 2 feet thick, had been found lying about 20 feet above the Fell Top Limestone: it was worked some years ago, but was now abandoned. Mr. Westgarth Forster, in his section of the Weardale measures, only mentioned four other thin seams of coal below the Fell Top Limestone, the thickest of which he gives as 1 foot 6 inches; and it would therefore appear that many of the seams mentioned by Mr. Simpson in his valuable paper, as now being worked in Northumberland, either do not continue or have become much thinner in south-western Durham; and as strengthening this assumption it may be taken as significant that in a recent paper on the Weardale limestone written by

Mr. A. L. Steavenson, whose knowledge and experience of the district is very considerable, no mention is made of any workable coal-seams below the Millstone Grit.*

In estimating the amount of coal likely to be found in the seams of the Millstone Grit and Mountain Limestone, he (Mr. Hendy) thought that it was very essential that the mining-engineer should carefully consider the probable manner in which these coals were formed. It seemed in every way likely that, at the time of the deposition of a group of rocks, the origin and character of which are so eminently marine as the Mountain Limestone, the land-surfaces upon which coal-plants, etc., could flourish would be limited. Speaking of the coal-seams which occur in the Gannister, Sir Charles Lyell remarked that "in some instances the vegetation did not grow where it became mineralized but was carried by water-power from some other locality and deposited."† Other geologists who have studied the character of the coal-seams in the Mountain Limestone have expressed the opinion that some of these seams have evidently been formed from accumulations of sea-weeds, fucoids and other marine plants. He thought that it might be fairly argued that workable coal-seams formed by such actions as those that he had quoted, would be exceptional, and a careful examination of the fossils above, and in, the seams of the Mountain Limestone of Northumberland, would probably yield much interesting information as to the origin of these coal-seams and throw further light on these questions. Whether or not these theories were correct, it certainly appeared evident that the physical conditions prevailing at the time of the formation of the Mountain Limestone coal-seams, were different from those existing when the formation of the seams in the Upper Coal-measures took place, and that they were not so favourable for the dense growth of terrestrial vegetation in the former period as they were in the latter. Mr. Simpson's paper gave abundant proof that there are valuable seams of workable coal in the Mountain Limestone and Millstone Grit, but that they can be relied upon in the north of England to maintain anything like a workable thickness or quality over very considerable areas is, he thought, open to doubt, and more especially does this appear to be so in the south-western district of Durham.

* *Trans. Inst. M.E.*, 1901, vol. xxii., page 115.

† *The Student's Elements of Geology*, fourth edition, 1885, page 361.

Mr. J. B. Simpson, replying to the discussion, said that, no doubt, as Prof. Redmayne and Mr. Nevin had pointed out, there appeared to be a thickening of the formation going eastward and north-eastward. This was shewn also by Prof. G. A. Lebour in his geological map of Northumberland. The Chopwell bore-hole seemed to confirm this opinion, and it passed through what may be considered the representative of the Great Limestone about 335 feet deeper in the formation than shewn by Mr. Westgarth Forster in his section. In the eastern and northern districts, the Great Limestone appeared to occur still deeper in the formation. Mr. Burn's idea that the limestones were more broken up in the eastern portion of the coal-field seemed to be borne out by fact, and there was no doubt that there were more beds of limestone there than in the western district, but not individually of so great a thickness. As to Mr. Steavenson's suggestion that the outcrops of the beds should be more minutely examined, there is a great deal to be ascertained by this investigation being further carried out, although to conclude whether the seams already found in the uncovered Mountain Limestone occur under the regular Coal-measures can only be ascertained by actual borings and sinkings. Probably, as Mr. Morison suggested, there may be more hope in the northern districts. The remarks of Mr. Atkinson and other speakers are very interesting and valuable and tend to throw further light on the subject under consideration. He (Mr. Simpson) might add that a great deal is still to be ascertained and he suggested, to the younger members especially, that they would find a profitable and interesting study to the further investigation of the Mountain Limestone formation. Much had already been written about it by many of the members and others, but its importance becomes almost daily greater if, as the writer ventured to predict, there were workable seams lying under the present coal-field, as they would add many years to the duration of the great northern coal-industry.

The President (Sir Lindsay Wood, Bart.) moved a hearty vote of thanks to Mr. Simpson for his valuable paper.

Mr. M. Walton Brown seconded the resolution, which was cordially approved.

Mr. J. R. Gilchrist read the following description of "Garesfield Railway and Incline":—

GARESFIELD RAILWAY AND INCLINE.

By J. R. GILCHRIST.

The old wagonway was a very zigzag road, with a somewhat light section of rail, and was worked by two standing-engines with drums. It was a single line, the empty wagons being hauled up and the loaded traffic taking the rope down. It was found that this line was quite inadequate, and could not be made suitable for dealing with an increased tonnage, such as was required. The question was therefore considered whether a locomotive line could not be made right through, and various sections were taken over different routes; but it was found that to dispense with a self-acting incline would mean a much more expensive line, seeing that the distance would be almost doubled, and, moreover, it would have necessitated making arrangements with other landowners. It was, therefore, decided to have the self-acting incline as the middle section, and to use locomotives at the top and bottom respectively, conveying the traffic from the collieries to the top of the incline, and from the bottom of the incline to the company's staithes at Derwenthaugh on the river Tyne.

The length of the incline is about 8,700 feet: the bottom is situated near Winlaton Mill, on the northern bank of the river Derwent, and the top is near Garesfield farm. The gradient at the top is 1 in 14, the middle portion 1 in 21, and the bottom portion 1 in 19. The difference in level between the top and the bottom of the incline is 460 feet.

The incline is worked by two drums, A, 15 feet in diameter and 6 feet wide, and both drums are fixed on a shaft, 10 inches in diameter. The drum-house is placed at the junction of the empty-wagon roads, and the views (Figs. 13 and 14) show that the drum-house is elevated above the empty-wagon roads. The top of the drum-house is covered with an iron tank, used as a reservoir to store water for supplying the locomotives. Figs. 1

and 2 (Plate XXI.) shew the arrangements at the top of the incline. There are four sets of roads, the two middle roads in the dish being empty-wagon roads, with two full-wagon roads on either side, elevated on kips.

Approaching the incline-top is a long siding to permit of the locomotive getting round its load. The wagons are pushed upon the two kips, and divided equally between the two sides.

The loaded traffic serves to the rope, and the empty traffic falls into the dish, after being released from the rope. The arrangement of the rails on leaving the top of the incline is also

FIG. 13.—WESTERN FRONT OF DRUM-HOUSE.

shewn in Figs. 1 and 2 (Plate XXI.) and it will be seen that there is a pair of runaway-switches, B and C.

There are two chocks, D and E, and F and G, on each of the full-wagon roads, the loaded trucks remain behind the chock, D or F, and when a set of six wagons is to be got ready, it is lowered down by the attendant between the two chocks D and E or F and G. The rope is then attached to the loaded wagons, the chock, E or G, is opened; and the runaway-switch still being open, when it is found that the rope has got the weight of all the trucks, the runaway-switch, B or C, is closed by means of a small galvanized rope and lever, and the set of wagons is then at liberty

to proceed down the incline. From the top of the incline to meetings, the line consists of three rails, and the three rails joining the four rails at meetings by a V rail, obviate the necessity of points, which would have been indispensable had there only been two rails on the top of the incline-meetings.

From meetings, the four rails are continued to near the bottom of the incline, where there is a short length of single road from this point to the commencement of the full and empty roads (Figs. 3 and 4, Plate XXI.). The switches at the bottom of the incline are weighted, and are worked alternately by the loaded set

FIG. 14.—EASTERN FRONT OF DRUM-HOUSE.

passing over them. At the bottom of the incline, there are also four sets of rails the full-wagon roads being on the low level and the two empty-wagon roads adjoining each other on the high level. This is the reverse of the arrangement at the top of the incline, but it is required in order that, in this case, the empty wagons may serve to the rope.

All the sheaves are made of toughened steel, and the rollers between the rails are 9 inches in diameter by 10½ inches wide (Figs. 5 and 6, Plate XXI.), weigh 45 pounds, and run loose on the spindle. The outside dimensions are 10½ inches wide by 12½ inches in diameter on the flange. They are evenly balanced, and

continue to run for some considerable time after the end of the rope has passed the sheave. At the top and bottom of the incline, there is a curve of 2,640 feet radius, which necessitates the use of angle-curve sheaves (Figs. 7 and 8, Plate XXI.), the spindle in this case being fast. The sheave is $4\frac{3}{4}$ inches wide, $13\frac{3}{8}$ inches in diameter, and weighs 27 pounds.

The curve-sheaves at the left-hand side, on leaving the top of the incline, are placed between the rails; and, under ordinary circumstances, this would have been the same on the other side, but the sheaves are placed, in this case, on the outside of the rails to permit the bringing up or taking down of locomotives without having to remove these sheaves. This removal would otherwise have been imperative, if they had been placed in the middle of the road, as they cannot be set sufficiently low to suit the rope and to leave sufficient height above the rails to clear the works of a locomotive.

As the incline varies from 1 in 14 to 1 in 21, and it was desired to run with not less than six $10\frac{1}{2}$ tons loaded wagons, it was deemed advisable not to rely on a single wheel at the top of the incline, but to provide two drums, of the size already given, with powerful brakes, so that the load would be better under the control of the drum-attendant; and, moreover, should either rope break, in this case, it would not in any way affect the other set, whereas with an ordinary wheel, the one rope is connected to both full and empty sets of wagons, and hence any breakage of either the rope or the attachments of one set would affect both sets. It may be asked why four rails are used from meetings to the bottom, instead of two rails; but by having four rails, any break-away of the loaded set coming down cannot affect the empty set going up. Further, if the line below meetings had been either of two or three rails, any break-away of the loaded set above meetings would of necessity have dashed into the empty load, as the empty load would then have been brought to a stand-still, owing to the break-away of the full load. In addition, by having four rails near the bottom of the incline, the attendant, at the bottom, can see whether the switches are, each time, in their proper position; whereas if they had been placed half way up the incline, they might have been interfered with without anyone's knowledge, and thus cause serious breakages.

The sets generally consist of six $10\frac{1}{2}$ tons full and empty

wagons, but the gradient is sufficient for six loaded wagons to haul up five empty and one loaded wagon, or four empty and two loaded wagons, so that there is sufficient margin of power to bring up any loaded traffic that may be required. Occasionally, sets of seven wagons are run, but it is found that six trucks is a safe load, and as much as the attendant at the drums can safely control; but whether the number of wagons to the set be six or seven greatly depends upon the condition of the rails, as in dry weather, seven trucks in a set can be safely taken, though this cannot be ventured when the rails are greasy. There are two brakes to each drum, and the brakes are placed on both sides and around the drums. The brakes are controlled by wheels-and-gearing, and one wheel works the two brakes on the outsides of the drums, the other wheel works the other two brakes on the insides of the drums and, if necessary, the four brakes can be applied together. In the unlikely event of a breakage in the brake-gear of both drums, the attendant at the bottom would bring the set to a standstill by using the runaway switch, and the attendant at the top would also take means to throw the set off the road, by putting the points half-over or by placing some other obstruction on the rails.

The ropes are made of crucible steel, with six strands, and are 3 inches in circumference. One of these ropes was put on to the old wagonway in April, 1897, and was transferred to the new incline in July, 1899. It is still at work, and from all appearances it will last for some considerable time longer.

The method of attaching the rope to the trucks is as follows:— A $\frac{5}{8}$ inch chain, A, 6 feet long, is placed over the drawbar, under the body of the last truck, together with a piece of ash timber, B, 4 feet $1\frac{1}{2}$ inches long by 9 inches deep and from $4\frac{1}{2}$ to $5\frac{1}{2}$ inches wide, known as the *devil* (Figs. 9 and 10, Plate XXI.). The devil is slung by two small chains and S links, C, behind the wagon-buffers (or end-stanchions) of the truck; the two loose ends of the $\frac{5}{8}$ inch chain, A, are then brought under the devil, and together with the centre-chain, D, the truck is coupled to the rope-end chain, E, by a shackle, bolt and cotter, F. The devil is used on account of there being two curves on the incline. Had the incline been straight throughout, the devil would not have been necessary, as the rope would then have been properly laid upon the rollers. The object of the devil is to guide the rope

upon the curve-sheaves, and to prevent the rope from rising and throwing itself off the sheaves.

At the bottom end of the incline, the rope-end chain is only hung on to the centre-crook of the drawbar of the truck.

On the right-hand drum, the rope leaves from the top side; and on the left-hand drum, from the bottom side; the ropes being placed on the drums so as to be at the outside of the drums, when the empty set is cast off at the top of the incline. This provides for the rope that is lying down the incline being placed as far away from the set that is being landed at the top as possible. Otherwise, if the ropes were cast off at the inside of the drums they would be very near the trucks that have arrived at the top and might be a danger to the attendant in landing the sets.

Where the top rope touches the first two sheaves from the drum, there is a side-movement of the rope of about 3 feet, and instead of using one large drum-roller, over 3 feet long, which would entail considerable friction to make it move round, this roller is made up of 24 small sheaves (Figs. 11 and 12, Plate XXI.). The rope moves from one sheave to another, and each small sheave revolves instead of a long roller, and therefore greatly reduces the friction and also the wear-and-tear. Each of these small sheaves can be replaced separately, instead of, as in the other case, having to replace a long roller. Each sheave is $1\frac{1}{2}$ inches wide, 12 inches in diameter, and weighs 15 pounds. The axle is 2 inches in diameter.

Half-way from the top of the incline to meetings, there is a runaway-switch on either side (not shown in Figs. 1 and 3) worked from the top of the incline by means of a rope attached to a hand-winch. Below this point, there is no further provision until the bottom of the incline is reached, where a runaway-switch is placed on the single and full-wagon road immediately before it reaches the two full-wagon roads, and it is under the control of the attendant at the bottom.

In addition to the attendant at the drums, there is only one attendant at the top of the incline and one at the bottom, so that in all three hands are employed, together with one boy employed in oiling the sheaves.

The time occupied in completing a run, including the time spent in making the set ready at the top and the bottom, varies from 15 to 17 minutes, of which 7 to 8 minutes are occupied in the

running from start to finish; and when the sets are in full running the speed ranges from 20 to 25 miles an hour. Under ordinary conditions, 4 sets are run in an hour, equal to 24 trucks, or 240 tons of coal per hour; but with an additional workman at the top and the bottom this quantity could be considerably increased, and 6 sets have actually been run per hour, that is, 36 trucks, or 360 tons of coal. There would be no difficulty in running 3,000 tons in an ordinary day of 10 hours working.

Since the incline commenced running 2½ years ago, there has not been the slightest accident in its working, and it has fully met all requirements.

Mr. P. KIRKUP (Birtley) asked, with regard to the appliance described as the "devil," whether this was used to keep down the rope and make it strike into the sheaves when going round curves.

Mr. J. R. GILCHRIST said that it was so used.

Mr. HENRY LAWRENCE (Newcastle-upon-Tyne) remarked that the application of a series of rollers, instead of having one only, was not new, but the system of oiling was original: one hollow fixed spindle went through the whole of the rollers which turned round on it; and opposite the centre of each roller was an oil-hole, so that it was self-oiling.

Mr. J. D. TWINBERROW (Newcastle-upon-Tyne) wrote that he was gratified to find that the incline and the drums for working it had hitherto met all requirements, more particularly since the responsibility for the design of the machinery rested with Mr. G. H. Sheffield and himself, and they had not hesitated to introduce features which might be considered to be of a somewhat experimental nature. He appended some particulars in tabular form, showing the general specification, with an estimate of the stresses on the rope and of the speed of working. It will be noted that the load hauled in daily work is in excess of that originally contemplated; it is also apparent that the auxiliary power might be dispensed with under all ordinary conditions of weather and traffic; and he believed that no delay had arisen owing to the absence of the steam-power for which provision had been made in the designs. He considered that any excessive weight in the drums was very undesirable, because an increase in the mass of the moving parts prolonged the period during which acceleration

Paper on

CLINE.

DRA
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DINGS

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SIDINGS

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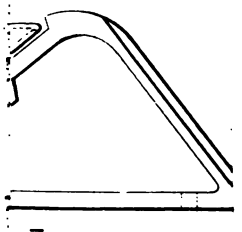

. 7.

was taking place, and it also required a larger axle with a greater weight on the bearings, thus increasing the moment of the frictional resistance. The drums were accordingly made entirely of steel, each drum had two cast-steel bosses, halved upon the axle, each boss carried eight radial arms of bulb T section, plated flush outside and braced transversely by L bars. The radial arms supported the brake-races and shill-boards, which were segmental castings of steel having an inwardly projecting flange to which the rim-plates were rivetted. The plates are not otherwise stiffened or supported, as they are designed to resist the cumulative stresses due to the superimposed coils of rope, which are laid on under the maximum tension, purely by circumferential compression. The band-brakes are applied in independent pairs, but each pair has one band on each drum, so that the retardation is applied to both drums under all circumstances.

The running speed appeared to be considerably higher than that customary in self-acting inclines: this was an indication of the excellent character of the permanent way and of the skilful manner in which Mr. Gilchrist had arranged the guide-sheaves and provided for hooking on and casting off the sets on a practical and safe system. He would be glad to know whether Mr. Gilchrist found that bull-headed rails in cast-iron chairs were preferable to flange-rails for roads of this description: it occurred to him that the corrosion, set up by cinder-ballast in contact with the thin flanges, would be an objection to the latter type. The action of this class of ballast was very destructive to the floors of steel-bridges, and it was a good practice to replace it with broken stone or other non-corrosive material, for a length of several yards on each side of such bridges. Cinder-ballast was considered moreover to be bad for the ropes, which were liable to pick up gritty matter therefrom. Local conditions were naturally of paramount importance in determining the laying-out of an incline-railway; but, speaking generally, the most economical solution of the problem of connecting two railways at different levels would be found in continuing the adhesion-roads as far as possible up the valley and along the hill-side respectively, and in making the incline as direct and short as possible, as the only practical limit to the gradient was that at which the loads were liable to be shifted by the inclination of the cars.

It appeared that the working of points and signals at long distances by means of electric or pneumatic power would lead to an economy in the cost of these railways, as a single line with a passing-place would meet requirements if the points were controlled with absolute certainty from the brakesman's cabin: runaway switches could be worked by similar means, and the provision of a simple interlocking gear would ensure the correct working of the points for the respective sets.

General Specification. The working of the incline shall be self-acting, and each set of 5 laden wagons shall draw up 5 empty wagons.

Two drums shall be fixed upon a single axle, a separate rope shall be provided for each drum; and the ropes shall be coiled on the drums in opposite directions. The diameter and width of the drum shall be such that the entire length of rope may be wound up in not more than 3 complete coils. The internal width of the drum-house shall not exceed 25 feet.

The running speed shall not exceed 20½ miles per hour, say 30 feet per second. The machinery shall be capable of lowering 3,000 tons per working-day. An auxiliary engine shall be geared at will to the drums for the purpose of drawing up a laden wagon.

NOTE. The addition of a laden wagon involves an average increase of 20 cwts. in the resistance up the incline, and the maximum speed of the drums is 39 revolutions per minute. Therefore, the engine, when geared at 6 to 1, makes 234 revolutions per minute.

In order that the engine may exert a tractive force of 20 cwts., at any speed, it must be capable of indicating 153 horsepower at the above speed, because 20 cwts. at 30 feet per second is equal to 122 horsepower, and the efficiency of the engine and gearing may be taken at 80 per cent.

Weight to be moved:

	Tons.	Cwts.
10 wagons at 6 tons 6 cwts. each	63	0
5 loads of coal at 10 tons 10 cwts. each	52	10
6,100 yards of rope at 6 pounds per yard ..	16	6
2 drums of 15 tons each, referred to their radius of gyration: = W × rad. ÷ R	27	0
	158	16

Tension on Rope:—

	Tons.	Cwts.	Tons.	Cwts.
5 loaded wagons on incline of 1 in 15 ...			5	12
5 empty wagons on incline of 1 in 94 ...	1	11		
Weight of rope	0	9		
Tractive resistance	0	14½		
Friction of ropes and machinery	0	10½		
			3	5
Net tractive force			2	7
Net tractive force, with laden wagon added			1	7

Time per Journey.—A tractive force of 2 tons 7 cwts. acting on a mass of 158 tons 16 cwts., produces an acceleration of 0·5 feet-second per second. The time required to attain the working speed is (30 × 1 ÷ 0·5 =) 60 seconds. The distance travelled during acceleration is (½ × 0·5 × 60 seconds =) 900 feet; the remaining distance of 8,070 feet is traversed in 269 seconds; and adding 11 seconds for stopping, the total time of the journey is 340 seconds, or 5 minutes 40 seconds.

When a laden wagon is added, the journey may be completed without the aid of the engine in the following time:—A tractive force of 1 ton 7 cwts. acting on a mass of 175 tons produces an acceleration of 0·248 feet-second per second. The time required to attain the working speed is (30 × 1 ÷ 0·248 =) 121 seconds. The distance travelled during acceleration is (½ × 0·248 × 121 seconds =) 1,815 feet; the remaining distance of 7,155 feet is traversed in 238·5 seconds; and adding 11½ seconds for stopping, the total time on the journey is 371 seconds or 6 minutes 11 seconds.

The speed shall be controlled by the application of the brakes, so soon as the maximum velocity is attained.

Mr. J. R. GILCHRIST, replying to the discussion, said that he preferred bull-headed rails and cast-iron chains to flanged rails, because they were less liable to corrosion from cinder-ballast and further that the gauge of the way could be better maintained. With good permanent way there was less liability to derailment of the wagons, and as there had not been a derailed wagon since the starting of the incline, that was sufficient evidence of the character and condition of the permanent way. Cinder-ballast was no doubt detrimental to rails and chairs, but, with ordinary attention, the ballast could be kept from coming into contact with them. The ballast should not be allowed to rise above the top of the sleepers and the space below the rails and between the sleepers should be kept clear. The ropes did not suffer from the cinder-ballast as the ballast was kept below the level of the tops of the sleepers and the sheaves being spaced at the requisite distances apart the ropes never came into contact with the ballast. Cinder-ballast is very suitable for railways because it makes an elastic bed for the sleepers; and as it is a waste-product from collieries, it could not be put to better use than in ballasting the railways. The adhesion roads were continued at the top and bottom of the incline as far as possible, so as to give the shortest practicable length to the incline at Garesfield, and this rule should be enforced in all cases. The working of the points and run-away switches could hardly be left in the case of the Garesfield incline to the brakesman, who had already sufficient work to occupy his attention. It was, however, a question for discussion as to

whether a single line with a pass-bye, and similar arrangements as existed at Garesfield was the most economical, all things being considered, as with the former arrangement the labour-cost would be greater, but the actual laying out and working must be left for decision in each individual case. He (Mr. Gilchrist) did not claim anything new or novel in the series of small sheaves used instead of one long roller and his paper was simply a description of what was used in actual practice.

The CHAIRMAN (Mr. J. S. Dixon) moved a vote of thanks to Mr. Gilchrist for his valuable paper.

Mr. A. L. STEAVENSON seconded the resolution, which was cordially approved.

A paper was read by MR. H. HUMPHRIS on the "Driving of an Inclined Tunnel 496 yards long and a Tunnel 842 yards long; and a Description of a New Method of Slate-quarrying in North Wales."

MR. DAVID BURNS read a paper on "The Correlation of the Beds of the Carboniferous Series in the North-east and North-west of England."

A paper was read by MR. JOHN KIRSOPP, jun., on "Coal-shipment and the Laying-out of Staithe-heads."

Mr. THOMAS DOUGLAS (Darlington) moved a vote of thanks to Mr. J. S. Dixon for presiding over a section of the meeting.

Mr. H. C. PEAKE (Walsall) seconded the resolution, which was cordially approved.

Mr. ARTHUR SOPWITH (Cannock Chase) moved a vote of thanks to the North of England Institute of Mining and Mechanical Engineers for the great trouble that they had taken in connection with the arrangements of the meeting, for the intellectual food provided for their edification, and for the entertainment, visits to works and collieries, etc., which they were soon to enjoy.

Prof. REDMAYNE (The University, Birmingham) seconded the resolution, which was cordially approved.

Sir LINDSAY WOOD, Bart., returned thanks on behalf of the North of England Institute of Mining and Mechanical Engineers.

Mr. N. R. GRIFFITH moved a vote of thanks to the President (Sir Lindsay Wood, Bart.) for his services in the chair. He remembered Sir Lindsay presiding at a meeting of the North of England Institute of Mining and Mechanical Engineers held in London some 26 years ago; he had not seen much of him in the interval, but he had found him as efficient in Newcastle-upon-Tyne as when he occupied the chair at their meeting in Great George Street.

Mr. J. G. WEEKS seconded the resolution, which was carried with acclamation.

The PRESIDENT (Sir Lindsay Wood, Bart.) said that he was much obliged to the members for their appreciation of his services.

The following notes record some of the features of interest seen by visitors to collieries, works, etc., which were, by kind permission of the owners, open for inspection during the course of the Newcastle-upon-Tyne meeting on September 16th, 17th, 18th and 19th, 1902:—

"NEWCASTLE CHRONICLE."

The members visited the printing works of the *Newcastle Daily Chronicle*, and were shown the details of the production of the special edition of the *Evening Chronicle*, including the operating of the linotype machines, and printing, folding, despatching, etc., of the paper.

WEST SLEEKBURN COLLIERY.

West Sleekburn colliery is one of a group of four collieries belonging to the Bedlington Coal Company, Limited. It is situated in the parish of Bedlington, about 3 miles north-west of Blyth and about 16 miles from the river Tyne.

There are two pits, the downcast shaft being 15½ feet, and the upcast shaft 9 feet in diameter.

Furnace-ventilation, which prevailed from 1862 to 1901, had so corroded the tubbing that in 1898 it was found imperative to reline the upcast shaft with new tubbing, and in so doing to reduce its diameter from 9 feet to 8½ feet for a length of 220 feet. This, in its turn, necessitated the removal of the upper set of lifting-pumps from this shaft, and its being placed in the downcast shaft, and the employment of a mechanical ventilator, so as to avoid the danger of further corrosion and to increase the air-current of the mine.

Three seams of coal are being worked, namely:—

	Thickness. Ft.	In.	Depth at Shaft. Feet.
Yard Seam	2	9	498
Bensham Seam	2	6	612
Low Main Seam	5	0	696

The output is a little over 800 tons per day, and affords employment to 670 men and boys on the surface and underground.

The system of working is bord-and-pillar in the Low Main seam and chiefly longwall in the other seams.

The seams have a rise to the south-west of about 1½ inches per yard. There is a dip-fault to the north of about 636 feet on the extreme northern boundary.

The winding-engine is of the type that in 1862 found general favour in the north, namely:—A vertical cylinder, 52 inches in diameter by 6 feet stroke, with a drum, 19 feet in diameter.

The pumping-engine has a vertical cylinder, 64 inches in diameter by 7 feet stroke, with a cast-iron beam weighing 40 tons. On the western end of the beam is a lifting and a forcing set. The bottom set of pumps, 18 inches in diameter and 7 feet stroke in the pit, lifts from the Low Main seam standage, 336 feet to the mid-shaft standage drift; and from this point to the surface, a ram-set, 18 inches in diameter and 7 feet stroke, forces a height of 402 feet to bank, the rising main being made of steel pipes, 17 inches in diameter, with cast-steel flanges, rivetted to the pipes. The eastern end of the beam carries a balanceweight of 12 tons.

The fan is driven by a compound tandem engine, fitted with Corliss valve-gear, the high- and low-pressure cylinders being 13 inches and 24 inches respectively in diameter by 36 inches stroke. Steam is supplied at a pressure of 100 pounds per square inch.

The governor is cutting-off so as to maintain at a speed of 50 revolutions per minute, a fan of Waddle type, 35 feet in diameter, producing 130,000 cubic feet of air per minute at a water-gauge of 1·70 inches, and 65 indicated horsepower. The fan-drift has an area of 132 square feet.

The electric-lighting plant consists of a trip-gear engine, with a cylinder 10½ inches in diameter by 22 inches stroke, supplied with steam at a pressure of 100 pounds per square inch. It runs at 90 revolutions per minute and drives a compound-wound dynamo supplying 100 ampères at a pressure of 220 volts, equal to 360 lamps of 16 candlepower.

The endless-rope hauling-engine at bank, with a cylinder 14 inches in diameter by 3 feet stroke, is geared 8 to 1. The main-and-tail-rope hauling-engine, with 2 cylinders, 20 inches in diameter by 4 feet stroke, is geared 2 to 1, and is fitted with drums, 8 feet and 7 feet in diameter, running loose on the shaft.

There are 8 Lancashire boilers, 7½ feet in diameter and 30 feet long, working at a pressure of 45 pounds per square inch; and 2 Lancashire boilers, 8½ feet in diameter and 30 feet long, working at a pressure of 120 pounds per square inch. The steam-pipes and some of the boilers are covered with asbestos silicate-cotton or slag-wool.

The screening-plant consists of 2 belt-screens, 4½ feet wide and 50 feet long, with lowering-ends worked by machinery; 2 nut-belts, 4½ feet wide and 57 feet long, and 3 feet wide and 38 feet long, and a small-coal or duff-belt, 3 feet wide and 63 feet long. The shaking-screens and belts are driven by a high-pressure engine, with a cylinder 13 inches in diameter and 24 inches stroke.

CAMBOIS COLLIERY.

Cambois colliery, owned by the Cowpen Coal Company, Limited, is situated on the sea-coast, 2¼ miles north of the town of Blyth.

There are two pits sunk on the royalty, 75 feet apart. The downcast and winding shaft, 15½ feet in diameter, contains pumps, steam-pipes and electric cables. The upcast and ventilating shaft, 14 feet in diameter, is used as a relief shaft, in case of an accident happening to the downcast shaft.

The Low Main seam is worked at a depth of 636 feet and the Yard seam at 435 feet; and the coal from the Yard seam is run down a drift, 1,560 feet in length with a gradient of 1 in 12, to the level of the Low Main seam.

The Low Main seam, with an average section of 5 feet, is worked by the bord-and-wall system, and the workings extend 8,000 feet under the North Sea.

The Yard seam, with an average section of 2⅔ feet, is worked by the longwall system: all the coal is removed, and the engine-planes are made in packed roads.

The vertical condensing winding-engine, built about 1863, has a cylinder 65½ inches in diameter and 7 feet stroke, with a rope-drum, 22 feet in diameter. Steam is supplied at a pressure of 20 pounds per square inch. The pulleys are 16 feet in diameter. Plough-steel ropes, 4½ inches in circumference, are used. The weight of the cages and ropes is counterbalanced by an iron-wire balance-rope of the same size as the winding-rope, attached to the bottom of the cages and running in a groove (without a wheel) in the bottom scaffold. Four tubs, each carrying 13 cwts. of coal, 2 tubs on a deck, are raised at a lift.

The haulage is on the main-and-tail rope system, worked by three Fowler semi-portable engines. Two of the hauling-engines have cylinders 14 inches in diameter, and the third has cylinders 12 inches in diameter, and all of 14 inches stroke, and geared 3 to 1. Steam is supplied at a pressure of 70 pounds per square inch. The steam is brought down the shaft by a range of wrought-iron pipes, 9 inches in diameter, secured by steel-channel collarings, every 15 feet, and fitted with three expansion-joints in the range. Thirty-eight tubs are run in a set in the Low Main seam, and 28 in the Yard seam. The haulage-ropes are made of improved steel, 2½ inches in circumference. The average distance hauled is about 6,000 feet from seven landings, the farthest being 8,700 feet, and the nearest 3,120 feet.

The ventilation of 150,000 cubic feet per minute at 1 inch of water-gauge is produced by means of a furnace, with a fire-grate area of 126 square feet, burning duff and refuse-coal.

The horizontal pumping-engine, placed at the bottom of the downcast shaft, has 2 cylinders each 22 inches in diameter, and 2 ram-pumps, 9 inches in diameter, all of 5 feet stroke, and is capable of dealing with 400 gallons of water per minute.

The heapstead is carried on cast-iron columns with rolled-iron girders, and is covered and roofed with corrugated iron. The screening-plant is capable of dealing with 1,500 tons of coal per day. It comprizes three jigging-screens and picking-belts, and one small coal-belt. Each screen is arranged so that, by altering a trap in the small-coal hopper, the small coal can be diverted on to the main picking-belts should unscreened coal be required. The picking-belts are 75 feet long and 4 feet wide, and travel at the rate of 75 feet per minute. The full tubs are conveyed from the weighing-table to the tipplers by creeper-chains, and after teaming are raised by steam-lifts, which in ascending turn a quarter revolution to the level necessary to enable the tubs to gravitate back to the shaft. The coal, from the tipplers, falls on to spreading belts rising 1 in 7½ to the jigger-screens. The whole of the screening-plant is driven by an horizontal engine, fitted with automatic expansion-gear, with a cylinder 12½ inches in diameter and 26 inches stroke.

Steam is generated in 7 Lancashire boilers, 28 feet long and 8 feet in diameter, working at a pressure of 100 pounds per square inch; and 5 Lancashire boilers, 28 feet long and 7 feet in diameter at 45 pounds per square inch. All the boilers are fired with washed duff coal. The high-pressure steam is reduced to suit requirements by being passed through reducing valves.

The electric-power plant consists of a 40 units dynamo, driven by an horizontal engine, with a cylinder 13½ inches in diameter and 30 inches stroke, supplied with steam at a pressure of 80 pounds per square inch. The current is conveyed to 6 pumps underground, situated at distances varying from 4,500 to 7,500 feet from the generating-station. Each pump is driven by a 6 horsepower motor. The shaft-cables, with 19 wires of No. 13 Birmingham wire-gauge, have a resistance of 4,000 megohms; and the underground cables range from 19 wires of No. 14 wire-gauge to 7 wires of No. 17 gauge, with a resistance of 2,000 megohms. The steam for this engine is generated in a locomotive type of boiler at the power-station. An Arons wattmeter is fixed in the engine-house on the main cable, in order that the output of the dynamo may be continuously recorded. This plant has been in continuous use for the last 8 years.

The under-clay and blue-shale, sent out of the mine, is manufactured into bricks by a machine with an output of 10,000 bricks

a day. The machine is driven by an engine, similar to that driving the screening-plant, and takes its steam from the main boilers. The bricks are burnt in ordinary kilns, each holding 8,000 bricks.

About 300 tons of small coal per day can be treated in the coal-washing plant, which consists of an elevator with stamped-steel buckets, a Robinson washer, and two revolving duff-riddles, each 13 feet long and 4 feet in diameter, with a gauze of $\frac{3}{16}$ inch mesh, all driven with chain-drives by an engine of the same dimensions as that working the screening-plant. When nut coal is being made, the duff, taken from it, can be washed at the same time.

A private railway, 2 miles in length, connects the colliery with the Cowpen Coal Company, Limited's staithes on the river Blyth. There are two shipping-staithes, with two spouts each. The west staithe is 40 feet, and the east staithe 36 feet, above high-water mark, and there is a depth of 24 feet at low-water at each. The east staithe is fitted with an anti-breakage apparatus, which has received the approval of the Admiralty. It consists of a box, holding $2\frac{1}{2}$ tons of coal, made in halves and hinged at the top, and slung to a crane. When full, the weight of the coal carries the box to the bottom of the hold of the ship: there, the catch holding the halves together is released, and the coal is deposited in the bottom; the box then closes automatically and is drawn again into position for loading by means of counterbalance-weights on the crane. This operation is continued until a cone is formed, with its top level with the hatchway, the box is then housed and the loading continued in the ordinary manner. One of Messrs. Bordes' four-masted sailing-ships, taking 3,800 tons of coal to Valparaiso, was recently loaded with this apparatus.

THE IMPROVEMENT OF BLYTH HARBOUR.

Blyth harbour, situate about the centre of the Northumberland coal-field, is the natural port of shipment for upwards of 40 collieries. Although coals have been shipped at the mouth of the river for upwards of 600 years, it is only during the last 20 years that Blyth has risen to prominence as a coaling-port. From 1813 to 1867, the harbour consisted of a short length of

the river-channel, nearly dry at low water, having a few small coaling-staithes on the south side, and a ballast-quay on the north side. The sea-channel of the river Blyth runs south-south-eastward, following approximately a line of fault in the rocks which form an extensive reef, dry at low water, upon its eastern side.

In 1856, a pier, consisting of timber-framing, enclosing a hearting of rubble-stone, was built upon this reef; and on the west side of the channel a training jetty of timber was constructed. At this time, the channel, although dredged to a depth of 4 feet at low water, was shoaled by every storm to about low-water level. In 1867, two coaling-staithes were opened at the north side and a depth was dredged alongside sufficient for vessels of 1,200 tons.

This condition of the harbour obtained until 1881, when the Blyth Harbour Commissioners, in conjunction with the North-eastern Railway Company, constructed two coaling-staithes at the south side. In 1885, a new west pier was constructed to protect the channel from shoaling upon that side, and the east pier was extended in solid concrete. In 1887, a new entrance-channel, having a depth of 10 feet at low water, was dredged about 210 feet to the west of the old channel, thus clearing a reef of rocks, which extended on the line of the old channel for 1,500 feet outside of the pier-head, the great cost of removing which would have made it impracticable to provide a deep-water channel upon the old line. In 1888, two additional coaling-staithes were constructed at the south side of the harbour. In 1896, the harbour was enlarged and deepened, and four additional coaling-staithes were constructed on the north side. In 1898, the entrance-channel was widened, and deepened to 16 feet at low water. In 1899, a new south harbour of 25 acres in area was completed, having a depth varying from 30 to 38½ feet at high water, with wharves, cranes and railway-connections.

The following is a summary of the improvement of the harbour during the last 20 years:—In 1882, the harbour-area was about 25 acres and, except at the Cambois staithes, was practically dry at low water; it could not accommodate more than about 40 small sailing-vessels, while the channel to sea was frequently shoaled to about low-water level.

At the present time, the area of the harbour is about 83 acres, the depth varies from 22½ to 38½ feet at high water, and it is

capable of accommodating over 100 large steamships, and ships up to 10,000 tons capacity have used the harbour. The sea-channel has a depth of 15 to 16 feet at low water, and is capable of being deepened to 20 feet.

The following shews the increase in the coal-shipments:—

	Tons.		Tons.
1883	146,264	1893	2,342,020
1884	362,879	1894	2,643,778
1885	526,667	1895	2,534 558
1886	561,749	1896	2,506,916
1887	585,484	1897	2,722,024
1888	1,018,335	1898	3,033,976
1889	1,263,327	1899	3,297,596
1890	1,715,406	1900	3,318,010
1891	2,047,480	1901	3,230,885
1892	2,157,140	1902	3,279,350

In addition to coal-shipments there is a considerable import-trade in timber. There is also an extensive shipyard, and five large graving-docks at the port.

The chief improvements at present in progress are the widening of the entrance-channel, by two steam-hopper dredgers, and the reconstruction of the old east pier, by enclosing it in concrete.

SEGHILL COLLIERY.

The output of about 1,580 tons of coal per day is drawn from two shafts.

The colliery is ventilated by an open-running fan, 35 feet in diameter, driven by a Corliss engine with a cylinder 16 inches in diameter by 3 feet stroke, fitted with sugar-tong-clip valve-gear. The engine is controlled by a governor, which varies automatically the cut-off and maintains a regular speed, even when the steam-pressure varies. The speed is readily altered by changing the weights placed on the governor, and this can be easily effected while the engine is running. The results of experiments, at speeds of 40 and 60 revolutions per minute, are recorded in the following table:—

No. of Revolutions of Fan per Minute.	Volume of Air per Minute.	Water-gauge.	Indicated Power of Engine.	Useful Effect
	Cubic Feet.	Inches	Horsepower	Per Cent.
40	133,952	1·00	42·93	49·17
60	205,932	2·15	133·94	52·09

A vertical engine, with a cylinder 9½ inches in diameter and 9 inches stroke, running at 200 revolutions per minute, drives a dynamo of 15 horsepower. The current is conveyed to a motor of 10 horsepower placed in the Low Main seam, driving a three-throw ram-pump, delivering 100 gallons of water per minute against a vertical head of 120 feet.

The main-and-tail-rope haulage is worked by an horizontal engine, with a cylinder 13½ inches in diameter by 30 inches stroke, fitted with valve-gear controlled by a governor, which automatically varies the cut-off and maintains a constant speed. The speed can be varied between 70 and 100 revolutions per minute by altering a spring attached to the governor, and this can be done while the engine is running. When not employed in hauling, the tail-rope drum can be put out of gear, and a clip-wheel put into gear; and the power is then transmitted by means of an endless wire-rope to the main differential ram-pump placed in the Low Main seam, and forces the water to the surface.

Two similar engines work the endless-rope haulage in the Blake and Yard seams, with 10½ and 7⅓ miles of rope respectively. The shop-engine has a cylinder 10½ inches in diameter and 22 inches stroke.

An engine, with a cylinder 10½ inches in diameter and 22 inches stroke, works the screens, including 4 shakers, 4 bar-belts for best coal, 45 feet long, with lowering arms; 2 belts for small coal; 1 duff-coal creeper; 3 tub-creepers; and 4 kick-ups. These are erected in an iron building with H girder steel legs.

All the engines are supplied with steam at a pressure of 100 pounds per square inch, except two old vertical condensing winding-engines, with cylinders 33 and 34 inches in diameter respectively, for which the pressure is reduced to 40 pounds per square inch. All steam is superheated. There is one range of 5 Lancashire boilers, 8 feet in diameter and 30 feet long. The pit and shops are worked by 3 boilers, mechanically fired with small-coal, mixed with some rough nuts.

The gas-works comprize 9 fire-clay retorts and two gas-holders.

MESSRS. LOCKE BLACKETT AND COMPANY, LIMITED: LEAD-WORKS.

In producing white-lead by the old Dutch stack-process, the metallic lead is cast into thin plates and placed upon earthenware pots containing dilute acetic acid, which in turn rest upon a layer of spent oak-bark; boards are placed above the lead, and other layers of bark, pots, lead and boards, are placed in the stacks until the stacks are full. After a period of about 3 months, the material is removed from the stacks, and a considerable proportion of the metallic lead is found to have been converted into hydrated carbonate of lead. This is crushed, washed, ground and dried, and then becomes the "genuine dry white-lead" of commerce. For painters' requirements, it is ground in refined linseed oil.

CONSETT IRON-WORKS, CONSETT.

Coal and Coke.

The Consett Iron Company, Limited, at the present time, own eleven collieries, extending over an area of 13,000 acres, and producing annually about 1,500,000 tons of coal. There are about 1,050 coke-ovens, producing about 600,000 tons of coke per annum. The greater proportion of the coke is consumed at the company's blast-furnaces, and the remainder is sold for use in blast-furnaces, etc., in Cumberland, Cleveland, and foreign pig-iron producing districts.

Pig-iron.

Blast-furnaces.—The 7 blast-furnaces are each 55 feet high, with a hearth 9 feet in diameter; height to top of bosh, 20 feet; diameter of the bosh, 20 feet; diameter of the throat, 14½ feet; and a bell with an opening of 10½ feet. There are seven tuyeres to each furnace. All the furnaces are fed with material by means of a bell and hopper, with a standard beam and hydraulic brake. The ore and other material for the furnaces is conveyed on a high-level approach, considerably above the tops of the furnaces, in bottom-door trucks, and is tipped from these into depôts, from which the charging barrows are filled.

Each of the furnaces is equipped with three Cowper stoves, varying from 65 to 90 feet in height, and from 21 to 24 feet in diameter.

The pressure of blast, now maintained, is 5 pounds per square inch, and its temperature on entering the furnace is about 1,200° Fahr. At the present time, six furnaces are in blast, and the seventh one is being relined. The six furnaces are making Bessemer pig-iron from imported Spanish and other ores, and produce on an average 750 tons per furnace per week. The limestone comes from the Consett Iron Company's quarries at Stanhope-in-Weardale.

The blowing engines are either of the beam or the vertical tandem type. There are six beam-engines, and two, being obsolete, will shortly be removed. The remaining four engines of this class have steam-cylinders, 50 inches in diameter; and blowing-cylinders, 100 inches in diameter, by 9 feet stroke, designed for a blast-pressure of 5 pounds per square inch. The two vertical tandem engines have steam-cylinders 50 inches in diameter; and blowing-cylinders, 100 inches in diameter, by 5 feet stroke, designed for a working pressure of 10 pounds, and in case of emergency will work to 15 pounds per square inch. They are fitted with Wheelock steam-valve gear and Adamson expansion-governors.

The steam required for driving the blowing-engines, etc., is raised in 19 double egg-ended boilers, each consisting of two lengths, 35 feet long by 4½ feet in diameter; and 12 double tubular boilers, each 31⅓ feet long, six of which are 7 feet in diameter, and the remainder 7½ feet in diameter. At the present time, three blocks of two boilers are being erected, each of the Babcock-Wilcox water-tube type, capable of working to a pressure of 160 pounds per square inch. The waste-gases from the stoves and boilers pass through a large underground flue to a fire-brick chimney, 250 feet high and 16½ feet in internal diameter, at the top.

The slag from the furnaces is removed in side-tipping ladles, with a capacity of 10 tons.

Engines and Brush dynamos, which generate the energy for lighting the works, are placed in Nos. 1 and 4 blowing-engine houses.

Steel Plates.

There are two melting-shops supplying ingots for the manufacture of steel plates. In the east shop, there is a range of nine Siemens open-hearth furnaces, six of 35 tons capacity, and

three of 28 tons. In the west shop, there are eleven similar furnaces, nine of 20 tons capacity, one of 28 tons and one of 35 tons. These furnaces are supplied with gas from a range of 33 steam-blown Siemens gas-producers. The two melting-shops produce about 4,200 tons of ingots per week.

The No. 2 cogging-mill is a 28 inches mill, driven from the No. 2 plate-mill engine, through steel bevel-gearing, and is reversed by means of a steam-clutch. The mill consists of one stand each of pinions and rolls, fitted with the usual live-roller frames, and screwing and edging gear. Cutting is done by means of a steam-hammer placed at right angles to the mill, and served by a steam jib-crane. This mill is capable of dealing with about 1,650 tons of ingots per week.

The No. 1 plate-mill has one stand of pinions, one stand of roughing rolls, and one stand of finishing rolls, each 6¼ feet long by 25 inches in diameter, driven by a high-pressure, direct-acting, non-condensing engine, with a fly-wheel weighing 70 tons. The steam-lift is capable of handling slabs weighing from 20 to 25 cwts. The capacity of the mill is equal to 400 tons of plates per week.

The No. 2 plate-mill is a clutch-reversing mill, and contains one stand of pinions, one stand of roughing rolls, and one stand of finishing rolls, each 7 feet long by 25 inches in diameter. The mill is driven by a high-pressure, direct-acting, non-condensing fly-wheel engine; and the reverse action is obtained by the five-wheel method and a clutch-motion. All the wheels, shafts and clutches are made of Siemens steel. The output of No. 2 mill is about 800 tons of plates per week.

Each of the preceding plate-mills has plate and scrap-shearing machines conveniently placed for its use. There are 6 Lancashire, 2 Babcock-Wilcox boilers, and 15 furnace-stack boilers, making a total of 23 boilers for driving these mills.

The No. 4 cogging-mill is a 45 inches mill, having one stand of pinions and one stand of cogging rolls, driven by an engine with a pair of coupled high-pressure, non-condensing, direct-acting cylinders, geared at 2½ to 1, the wheels, shafts and couplings all being made of Siemens mild steel. The mill is provided with live-roller gear on each side, and hydraulic edging gear on the delivery side. The top roll is balanced by hydraulic, and the screwing is effected by steam-power. In a line with the mill,

a large bloom-shearing machine is placed, driven by a high-pressure reversing engine, and provided with live rollers mounted in falling tables on the receiving and delivery sides of the shear. The ingots are heated in 6 vertical heating-furnaces, served by a steam-derrick locomotive crane. This plant is capable of cogging 2,600 tons of steel ingots per week.

The No. 3 plate-mill has one stand of pinions, one stand of roughing rolls, one stand of finishing rolls, and one stand of chequering rolls, the roughing and finishing rolls being each 6¼ feet long by 25 inches in diameter, and the chequering rolls 5½ feet long by 25 inches in diameter, and all are driven by a high-pressure, direct-acting, non-condensing fly-wheel engine, geared inversely as 1½ to 1. The mill is furnished with a similar steam-lift to that at No. 1 plate-mill, and it is also equipped with the necessary plate and scrap cutting-shears. It produces about 380 tons of plates per week.

The No. 4 plate-mill is a 28 inches clutch-reverse mill, driven by a high-pressure, direct-acting, non-condensing fly-wheel engine, the reverse action being obtained by the five-wheel method and a clutch-motion, and all gearing and shafts are made of Siemens mild steel. The mill has one stand of pinions, one stand of roughing rolls, and one stand of finishing rolls, these latter being 8 feet long by 28 inches in diameter. The delivery side of the mill is provided with a traversing steam-platform, constructed so as to work the plates to and fro through the rolls, and also to take them bodily from the roughing rolls to the finishing rolls; and the receiving side is fitted with live roller-frames. A 15 tons steam travelling-crane running overhead upon steel-built box-girders is used for roll-changing. There are 2 strong plate-shearing machines, each capable of cutting plates 1½ inches thick. The output of this mill is 1,250 tons of steel plates per week.

A battery of 14 hand-fired Lancashire boilers is installed outside of the roof area; and in addition there are, in the cogging-mills and plate-mills, 16 boilers, making a total of 30 boilers; 8 being vertical, 4 Lancashire and 4 Cornish boilers.

ANGLES, ETC.

The ingots for the angle-mills are supplied from the north melting-shop, containing 7 Siemens open-hearth furnaces, the charges for which are 28 tons. These furnaces are of similar con-

struction to those in the east and west melting-shops, but are laid out somewhat more conveniently, with ample space, and having unusually large and well ventilated valve-chambers. Gas is supplied from 15 Siemens producers, to the melting-furnaces, and these also are conveniently laid out for dealing with both coal and ashes. The ingot-producing capacity of these furnaces is 1,800 tons per week.

The 45 inches cogging-mill is driven by a high-pressure non-condensing engine, with 2 cylinders 45 inches in diameter by 5 feet stroke, fitted with piston-valves and Allan link-motion, and geared at 2 to 1. It comprises one stand of roll-housings, and one stand of pinions, seated upon cast-iron bed-plates. The mill, with live roller-gear on each side, is designed for dealing with slabs or billets. The capacity of this mill is about 2,500 tons per week.

The 32 inches angle-mill is driven by a reversing high-pressure non-condensing engine, with 2 cylinders 54 inches in diameter by 4½ feet stroke, fitted with piston-valves and Allan link-motion, and coupled direct to the mill by an inside crank-shaft and steel couplings. The mill, which is about 125 feet distant from the bloom-shear, has one stand of pinions, one stand of roughing rolls, and one stand of finishing rolls, all coupled through steel boxes and spindles. The capacity of this mill is about 2,000 tons per week.

The 22 inches angle-mill is driven by a reversing high-pressure non-condensing engine, with 2 cylinders 40 inches in diameter by 4 feet stroke, coupled through steel boxes and spindles in the same manner as the 32 inches mill. It comprizes one stand of pinions, one stand of roughing rolls, and one stand of finishing rolls, with live roller-gear on the receiving and delivery sides, and an inclined shoot on the receiving side. The live roller-gear leads from the mill to the billet-shear and steam circular sawing-machine; and on a line with these is a relief live roller-frame for distributing the rolled bars, as in the 32 inches mill. The capacity of this mill is about 1,600 tons per week.

The 12 inches guide-mill is driven by a high-pressure non-condensing fly-wheel engine, with 2 cylinders 30 inches in diameter by 2½ feet stroke, fitted with piston-valve and governor-gear. It consists of one stand of pinions, one stand of roughing rolls, one stand of finishing rolls, and two stands of guide-rolls,

all coupled through steel boxes and spindles. A steam circular sawing-machine and billet-shear are likewise provided. This is a reheating mill, and two furnaces are conveniently placed, with stack-boilers attached. The capacity of this mill is about 350 tons per week.

The cogging-mill is served by a 25 tons overhead square shaft steam-crane; and two overhead cranes, each of 15 tons capacity, with attached boilers, traverse the three angle-mills and roll-turning shop, these being placed in one line and under one roof.

The roll-turning shop is placed at the end of the 32 inches mill, and contains three powerful lathes, each driven by its own engine.

The hydraulic plant comprizes two sets of Worthington high-pressure pumps, one accumulator and tank, with automatic governor gear attached, working to a pressure of 700 pounds per square inch.

There is a battery of 18 Lancashire boilers fired by automatic stoking-gear. They are arranged in pairs, and work through nine iron chimneys lined with brick. The mill-furnace boilers are of vertical type, with one internal flue fitted with cross tubes, and stand upon cast-iron columns. All the boilers are designed to carry a pressure of 100 pounds, and in daily working are pressed to 80 pounds per square inch. The steam-pipes, from 9 inches in diameter upwards, are made from Siemens mild wrought-steel in lengths up to 16 feet, welded from end to end, with solid flanges contracted and rivetted on.

The bar-bank is arranged at the southern end of the mills. Bar-skidding gear is provided, worked from the driving-engine through shafting, the friction-cones being set in motion by hydraulic-rams. The loading on the bank is done by two 3 tons steam locomotive travelling cranes, having 30 feet jibs.

There are the usual fitting, blacksmith, boilersmith, pattern-maker, joiner and other shops, where renewals and repairs to machinery and other plant are executed.

The foundry is situated at Crookhall, 1¾ miles from the main works, and has a capacity of 200 tons of castings per week. The plant consists of three cupolas, air-furnace, drying-stoves, loam-mill, and blowing-plant, with two 25 tons overhead steam-cranes, and one hand-power jib-crane. The ingot-moulds, and the whole of the castings necessary for mill and general ironwork repairs, are made here. There are pattern and blacksmith shops, and a brass-foundry.

The brick-works, about ½ mile from the iron and steel works, have a capacity of about 120,000 bricks per week. There are 10 brick-burning kilns, each equal to 18,000 bricks per load, fired by the waste-heat from four rows of coke-ovens immediately adjoining, the waste-gases from which are collected in one large flue, and, after passing through the kilns, are conveyed in small flues under the floor of the drying-shed. There are also a small mill and press for mixing and making ganister-bricks, which are burnt in two suitable hand-fired kilns.

The locomotives and locomotive-cranes are of various classes, and 55 are in general use. The locomotive repairing-shop is situated at Templetown, about 1 mile from the works, on the main line between the works and the collieries, and is furnished with all necessary tools and appliances.

DAWDON COLLIERY.

The first sod of the Theresa or south shaft was cut by the Marchioness of Londonderry, and the first sod of the Castlereagh or north shaft by Viscount Castlereagh, on August 26th, 1899.

Sinking operations commenced on April 17th, 1900.

Both shafts will be 20 feet in internal diameter when completed.

Theresa Pit.—The Theresa shaft is now 350 feet deep, and has 225 feet of cast-iron tubbing, and 96 feet of brick lining in it. The largest feeder yet met with in this shaft was 6,075 gallons per minute, at a depth of 196 feet from the surface.

The ground sunk through in this pit is as follows:—

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1.	Soil	1	0	1	0
2.	Strong clay	5	0	6	0
3.	Sand and gravel	3	0	9	0
4.	Marl with limestone-panels ...	6	1	15	1
5	Marl	22	6	37	7
6.	Limestone	6	0	43	7
7.	Strong marl	66	0	109	7
8.	Strong marl, in blocks	64	8	174	3
9.	Hard limestone	60	6	234	9
10.	Grey marl	4	7	239	4
11.	Grey limestone	73	4	312	8
12.	Grey and yellow limestone, into ...	37	4	350	0

Several small bore-holes have been put down from the bottom of this pit, and it has been found that the sand lies 19 feet below the present pit-bottom. The sand is 84 feet thick. It is thought that the sand is somewhat solidified, and that it will be sunk through without much trouble.

In this shaft, there are pumps capable of delivering 7,000 gallons per minute, namely:—Two 24 inches and one 25 inches pumping sets, and two vertical sinking-pumps, with cylinders respectively 24 inches and 16 inches in diameter by 24 inches stroke, each capable of pumping 1,000 gallons per minute from a depth of 300 feet.

Sinking operations in this shaft have been suspended until the north pit reaches the same depth, so as to permit of both shafts being taken through the sand together.

Castlereagh Pit.—The Castlereagh shaft is at present 190 feet deep. It has the same amount of brick lining as the other shaft, but has only one lift of tubbing, 33 feet long, completed. At present, another lift of tubbing, 53 feet high, is being inserted. The present feeder is the greatest yet met with, amounting to 4,480 gallons per minute.

The section of this shaft is:—

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1.	Soil	1	0	1	0
2.	Clay	5	6	6	6
3.	Sand and gravel	4	6	11	0
4.	Strong marl, with limestone	50	10	61	10
5.	Limestone, with marly partings ...	32	7	94	5
6.	Marl, with gullets	90	0	184	5
7.	Hard limestone, into	5	7	190	0

To clear the water from this pit, a drift has been driven from the Theresa shaft in a northerly direction, and a bore-hole, lined with steel tubes 9½ inches in internal diameter, has been put down into this drift, and the water, which runs downward, is pumped at the Theresa shaft. There is also a sinking-pump, similar to those in the other pit, hung in this shaft to pump the excess-water, which the bore-hole cannot drain off.

The water in both shafts is pumped into a drift, 90 feet below the surface, from which it runs to the sea-beach.

It is proposed, when the Castlereagh shaft reaches the same depth as the Theresa shaft, to put in four 30 inches sets of pumps —two standing sets and two sinking sets—for pumping the water. while going through the sand.

Engines, etc.—The sinking-engines have each two cylinders 24 inches in diameter, and a stroke of 4 feet. The drum is 6 feet wide, and 8 feet in diameter. The locked-coil rope is $3\frac{3}{4}$ inches in circumference. These engines will eventually be used as underground hauling-engines.

The pumping-engine for working the two 24 inches sets and one 25 inches set in the Theresa shaft has two cylinders, 36 inches in diameter and a stroke of 6 feet, and the flywheel is 24 feet in diameter.

The main crab-engine has two cylinders, 14 inches in diameter and a stroke of 3 feet; it is geared 16 to 1, and the rope is $6\frac{1}{2}$ inches in circumference. The cylinders of the ground crab-engine are 8 inches in diameter and a stroke of 14 inches: it is geared 30 to 1, and works with a rope $5\frac{1}{2}$ inches in circumference.

The foundations, $4\frac{1}{2}$ feet thick, of the permanent winding-engine houses have been built, their outside measurements being $66\frac{1}{2}$ feet by $48\frac{1}{2}$ feet, and $23\frac{1}{2}$ feet deep.

The permanent winding-engines will be of the Corliss-valve type, with cylinders 40 inches in diameter, and a stroke of 6 feet, and the drum will be 10 feet wide and 20 feet in diameter.

An engine is used for compressing air to drive the rock-drills used in the bottom of the pit.

Boilers, etc.—There are 8 Galloway boilers, each 30 feet long and 8 feet in diameter, fitted with two furnaces, $3\frac{1}{4}$ feet in diameter, working at a pressure of 100 pounds per square inch. There are also 3 locomotive-type boilers, but these are not being used at present.

There are four sets of Green fuel-economizers of 120 tubes each. The gases enter the economizer-flues at a temperature of 500° Fahr. and leave at 300° Fahr., and the water enters the economizers at 85° Fahr. and leaves them at about 240° Fahr.

The chimney for the Galloway boilers is 160 feet high, its base is 24 feet square, and the inside diameter at the top is 12 feet.

There are two water-softening tanks, each $15\frac{1}{2}$ feet by $15\frac{1}{2}$ feet

by 10 feet deep, holding 15,000 gallons each, and capable of treating 60,000 gallons per day. The water for boiler-feed purposes is softened in these tanks by the Archbutt-Deeley process, and the hardness, which is originally about 16 degrees, is reduced to 4 or 5 degrees. About 40 pounds of lime and 7 pounds of alkali are used for each tank treated, at a cost of about 0·46d. per 1,000 gallons.

SEAHAM HARBOUR WORKS.

The works under construction consist of:—(1) New Dock, 10 acres in extent, with 27½ feet of water at high water of ordinary spring tides; (2) entrance to dock, 200 feet long and 65 feet wide, with inner and sea-gates; (3) harbour-wall and sea-wall enclosing the quay-space; (4) North and South Piers, forming an outer harbour of 30 acres with an entrance, 300 feet wide; and (5) coal-tips, staging, etc.

The New Dock is built partly on the site of two old docks, namely:—The Old South and Old Dry Harbour, and partly on the foreshore. The Old South Dock is now being pumped dry. The excavation on the site of the Old Dry Harbour is completed, and that on the portion of the dock on the foreshore is in progress. The excavation is in limestone, which is blasted and then filled into wagons by steam-navvies. A good deal of water is met with.

The walls of the dock are built in cement-concrete, with a masonry-facing, for 13 feet from the top, finished with a granite-coping. The entrance is to be built in similar work. At present the western roundheads are built, and a cofferdam is under construction to enclose the remainder. This cofferdam, of concrete from 9 to 12 feet thick at the top, with a foundation from 12 to 20 feet wide, has been under construction for two years; large portions have been washed away during winter storms.

The North Pier is 1,335 feet long, 25 feet thick on the top for a length of 623 feet and 30 feet for 712 feet. The South Pier is 878 feet long, 20 feet thick on the top for a length of 578 feet and 25 feet for 300 feet. Both piers are built of concrete-blocks faced with freestone-ashlar. Those for the North Pier (which has to stand the heaviest gales) weigh 30 tons, and those for the South Pier 20 tons. The blocks are all made in the blockyard on the north side of the works, and those for the South Pier are taken round by a tunnel specially constructed for this purpose.

The blockyard is furnished with Taylor concrete-mixers. The gravel procured from the beach, and cement from the shed is taken up by the elevators to the mixers and passing through the mixers is led by narrow-gauge trucks to the various blocks. The blockyard is spanned by a goliath-crane of 100 feet span, capable of lifting 40 tons.

The blocks are set on a foundation of mass-concrete, which is laid on the rock under water by divers and levelled for the reception of the blocks. The piers are finished with a granite-coping on each side, and a subway runs the whole length of each and will enable the attendants to reach the lighthouse in stormy weather.

Owing to the exposed position, the preliminary work of enclosing the site, forming the ground for the blockyard, etc., has required considerable time. The severe storms in the autumn and winter of 1901-2 also caused considerable damage, the works being practically stopped for 6 months.

The plant in use on the works includes:—6 locomotives, 210 wagons, 3 steam-navvies, 8 cranes, 2 titan-cranes, 1 goliath-crane, 10 portable engines, 1 set of winding gear, 4 concrete-mixers, 11 steam-pumps, etc. About 400 men are usually employed.

HYLTON COLLIERY.

Hylton colliery is situated on the site of the Wear steel-works, on the northern side of the river Wear, about 2 miles above Sunderland.

Shafts.—There are three shafts: the east and west pits, each 20 feet in diameter, are used for coal-drawing, and the south pit, 15 feet in diameter, is the upcast and fan-shaft.

The east and south pits are sunk to the Hutton seam, with an average section of 4½ feet of clean coal, at a depth of 1,580 feet. The west pit has been sunk to the Maudlin seam, 5 feet 9 inches thick, at a depth of 1,440 feet. All three shafts are lined throughout with brick-walling.

Winding-engines.—The winding-engines at the east and west pits are in every way similar. They have 2 cylinders, 34 inches in diameter by 6 feet stroke, and are fitted with double-beat valves and automatic cut-off gear. The working steam-pressure is 120 pounds per square inch. The winding-drums are 20 feet in diameter on the cleading, which is of oak, 7 inches thick, fixed on

steel lagging-plates; they are fitted with strap-brakes worked by a foot-lever, in addition to powerful steam-brakes.

Winding-ropes, Pulleys and Cages.—The winding-ropes are of mild steel, 5¼ inches in circumference. The pulleys, carried on frames of steel lattice-work, are 20 feet in diameter; they are of German manufacture, the rim being built in segments and carried on the boss by tapered flat-steel spokes. The small cages, at present in use, will shortly be replaced by double-decked cages, carrying 4 tubs on each deck. An endless rope hung from the cage-bottoms counterbalances the winding-rope.

Heapstead and Banking-out Arrangements.—The heapstead is built on brickwork arches, the floor is of steel girders and concrete laid with a gradient, which allows the tubs on leaving the cage to gravitate to the tipplers, and, after being emptied, to run to the creepers at the back of the shafts, whence they are raised to a level from which they run automatically back to the banksmen.

The output of the colliery has, up to the present, been disposed of as unscreened gas-coal, and the jigging-screens which have been erected are not as yet in use as screens. All the coal is, however, passed over the picking-belts.

Ventilating Fan.—A Waddle fan, 25 feet in diameter at the blade-tips, is in course of erection, it will be driven by a tandem compound engine with cylinders, 18 and 30 inches in diameter by 24 inches stroke. This fan will replace a small furnace, which, up to the present, has produced ample ventilation; it is placed in the east pit at a depth of 940 feet, and, though only raising the temperature to a mean of 66° Fahr., it is producing a current of 80,000 cubic feet of air per minute.

Haulage.—It is intended to introduce an endless-rope system of main haulage; and secondary engines, placed inbye, having two cylinders 10 inches in diameter by 16 inches stroke, and driven by compressed air, will haul to the landings from the flats; some of these engines are already in use.

Air-compressors.—There are two Ingersoll-Sergeant two-stage air-compressors, one is already in use and the second is in course of erection. The steam-cylinders are 18 and 30 inches in diameter, the water-jacketted air-cylinders are 25¼ and 16¼ inches in diameter by 24 inches stroke. The air leaves the low-pressure cylinder at 38 pounds, and passes through the intercooler to the

high-pressure cylinder, where the pressure is increased to 100 pounds per square inch.

Lighting.—The whole of the surface and the shaft-bottoms are electrically lighted, the current being supplied from a Tyne dynamo driven by a 50 horsepower Robey engine. The output of the dynamo is 400 ampères at 110 volts at 600 revolutions per minute, being equivalent to 750 lamps of 16 candlepower.

Boilers.—One battery of 6 Lancashire boilers, 30 feet long by 8½ feet in diameter, is already seated, though only 4 are in use, supplying steam at a pressure of 120 pounds per square inch. A similar battery will be put down shortly to replace the old boilers of the steel-works, as they cannot safely be pressed beyond 75 pounds.

NEWCASTLE-UPON-TYNE CORPORATION TRAMWAYS: MANORS POWER-HOUSE.

The power-station for the tramway system is located almost in the centre of the area of supply, and consists of large steel-framed buildings, with brick-walls.

A connection, from the railway, runs at a high level over a timber and steel elevated road, and the coal is discharged direct from the hoppered railway-wagons into the bunkers above the boilers, from which it is fed by automatic weighing-machines into automatic stokers. For steam-raising purposes, there are 8 Lancashire boilers, each 30 feet long by 8½ feet in diameter, working at a pressure of 160 pounds per square inch, with economizer and natural draught. The brick-chimney is 177 feet high.

In the engine-house, there are 3 marine-type engines, fitted with Corliss valves, two of 1,000 horsepower each, and one of 2,000 horsepower. The engines are provided with surface-condensers, and Edward air-pumps.

Three dynamos are coupled direct to the three engines, and supply current at a pressure of 500 volts through a large switchboard to the traction-mains. In addition, current is supplied from the same switchboard by separate feeders for the arc-lighting of the town.

Circulating water for the surface-condensers is provided from the River Tyne, which is about ¼ mile distant from the station, and 90 feet below the level of the engines. Two large mains 24

inches in diameter, are run down to a pumping-station alongside the quay-wall, where two centrifugal pumps force the water to the power-station up one pipe, and the water returning by the other pipe, drives turbines, which help to drive the pumps, the surplus power, due to friction, loss of head, etc., being supplied by motors coupled direct to each pump.

There are at present 16½ miles of double tramway-track in use, and about 165 cars of various types, bogie and 4-wheeled, for which there is one car-shed in the centre of the town, another at the extreme northern end at Gosforth, and the third at the eastern end, at Byker. The latter forms also a machine-shop for repairs and building of cars.

SIR W. G. ARMSTRONG, WHITWORTH & COMPANY, LIMITED: ELSWICK WORKS.

The steel-works were opened in 1883, with the idea of supplying gun-steel to the Ordnance works, but of late years large quantities of outside orders have been undertaken.

The steel-works, at the eastern end of the Elswick works, extend over a length of 1,100 feet, and cover an area of about 50,000 square yards. The melting-plant comprises 8 furnaces, which are capable of a weekly output of upwards of 1,200 tons of steel, and ingots can be cast up to a weight of 80 tons.

The forging plant is worked hydraulically, and can turn out 120 tons of forgings per week. There are 4 large forging presses and several smaller ones. The largest of the presses exerts a pressure of 5,000 tons. The pressure required by the forging plant is supplied by 5 Corliss pumping-engines, each indicating 1,000 horsepower. Propeller-shafting has been forged under the forging presses in lengths of 80 feet, which shafting has afterwards been trepanned from end to end.

In the foundry, steel castings for gun and carriage work, marine and electrical general machinery and anchors, and the largest stem and stern-posts and rudder-frames are manufactured. The weekly output of castings amounts to about 60 tons.

There is an extensive plant of heavy machinery for dealing with forgings and castings.

The department employs about 2,000 hands.

NORTHERN WOOD-HASKINIZING COMPANY, LIMITED.

The haskin system of treating wood consists in placing the raw timber in a large steel cylinder or treating chamber, and superheated air is applied under great pressure. The high temperature, ranging from 300° to 400° Fahr., is sufficient to destroy the tendency to germinate, and to kill all fungi, germs and insect life in the wood; and to produce a much higher percentage of antiseptic and preservative matter than is found in untreated timber. With the high pressure employed, evaporation or bubbling of the essential oils or sap in the wood is entirely prevented, and the chemical changes which take place, as a consequence of the application of heat, penetrate to, and remain in, every particle of the fibre. Before removing the wood from the cylinder, it is allowed to cool down under the same pressure, with the result that the new compound arising from the heating of the natural fluids in the wood is consolidated with its fibre.

Haskinizing considerably lengthens the life of timber in actual use, and by its consolidation of the fibres of soft, succulent varieties of wood, which are thus made stronger and more durable, very important economies may be effected. The process is applicable to every species and variety of timber, fitting it for immediate use for every purpose, from the coarsest qualities suitable for outside work to the finest kinds required for structural and cabinet work, carving, interior decorations, etc. No extraneous matter is used in the process, and no offensive odours are emitted from the wood after treatment.

Tests of the transverse and crushing strength have been made of three logs of pitchpine. Each log was cut into three pieces, one of which was left in its natural state, a second was haskinized, and the third was creosoted, making nine pieces available for the experiments. The tests, as certified by Messrs. Kirkaldy & Son, indicated that the modulus of rupture by transverse stress was 14 per cent. higher for the haskinized wood than for the untreated, and 29 per cent. higher than for the creosoted wood. The crushing strength of the haskinized wood was 4 per cent. above that of the untreated and 7 per cent. above that of the creosoted wood. Chemical analysis showed that there was 27 per cent. of resinous preservative constitutents in haskinized wood, as compared with 10 per cent. in similar untreated wood.

NEWCASTLE-UPON-TYNE ELECTRIC SUPPLY COMPANY, LIMITED: NEPTUNE-BANK WORKS.

General Notes.—In June, 1899, the Walker and Wallsend Union Gas Company obtained Parliamentary powers to supply the urban districts of Wallsend and Willington with electric power, and proceeded, in January, 1900, with the erection of a power-station on a site midway between Carville and Walker, close to the Riverside branch of the North-eastern railway. In October, 1900, the Newcastle-upon-Tyne Electric Supply Company, Limited, purchased the entire plant put down by the Gas Company, with the exception of the cables and sub-station machinery installed for the purpose of supplying the works in the area in which the Gas Company had obtained Parliamentary powers. The Supply Company further entered into an agreement with the Gas Company, in which the latter undertook to buy electricity in bulk from the former. The Supply Company also obtained, further powers authorizing them to lay high-tension cables from their power-house at Wallsend to various sub-stations in Newcastle-upon-Tyne. At the same time, they decided to change their entire system of supply, which, up to this date, had been by means of single-phase alternating current generated at Pandondene power-station at a pressure of 2,000 volts, with house to house transformers. The new scheme included the generation of three-phase current at 5,500 volts, having a periodicity of 40 cycles per second, and the transformation of the same to continuous current by means of motor generators in sub-stations each designed to have a total capacity of 2,000 kilowatts. In the beginning of 1901, the work of changing the lighting network from alternating to direct current was started, the direct current being on the three-wire system (2 by 240 volts). It may be of interest to note that, since the Neptune-bank power-station started work, motors having the aggregate capacity of over 4,500 horsepower have been connected. These motors are used in all classes of trades, and vary in capacity from ½ to 50 horsepower.

Power-station.—The boiler-house, which is of corrugated iron, adjoins the engine-room on the south side. The dimensions of each building are 160 feet by 52 feet. On the north-east of the power-house lies the cooling-pond, where the circulating-water

is cooled by means of spray nozzles, capable of cooling 4,000,000 pounds of water per hour. This system of dealing with the circulating-water was adopted because of the great cost of pumping sufficient water direct from the river, which is some 60 feet below the level of the power-station.

On the other side of the power-house, is the testing-pond, which is capable of absorbing 1,500 kilowatts.

The overhead line (low-tension three-phase, and direct current) leaves the power-house on this side; it is used for a supply of current to the Neptune engine-works, and the Walker shipyard.

Boiler-house.—There are four batteries of Babcock-Wilcox boilers, each consisting of 2 boilers of about 1,000 horsepower. fitted with superheaters, mechanical stokers, etc. The working pressure is 200 pounds per square inch and the superheat ranges from 100° to 120° Fahr. Each boiler has a heating-surface of 4,020 square feet, and will evaporate 14,000 pounds of water per hour.

Among the fittings is an apparatus for determining the quality of the flue-gases. An economizer, with 280 tubes and the usual motor-driven scraper-gear, serves to heat the feed-water before entering the boilers.

The steam-pipes are made of solid-drawn steel tubes; one main header, 7 inches in diameter, supplies the main engines; and a separate header is used for the auxiliary engines.

The ashes are discharged into trucks in the ash-tunnel and are raised by an elevator at the south-eastern end of the house. An electric locomotive of 20 horsepower is used for conveying coal to the boiler-house from the railway.

Engines and Generators.—At present, there are nine sets varying from 50 to 1,500 kilowatts.

The engines of Nos. 1 and 2 sets are of 300 horsepower and drive two direct-current generators, which are used for supplying the direct-current network in Walker and Wallsend. The engines are compound, of the two-crank type, and run at 380 revolutions per minute. The generators are compound-wound and provided with equalizing switches. The armatures are slotted and are drum-wound. The magnets are of mild steel.

The No. 3 set is of 50 kilowatts capacity and generates current at 240 volts for exciting purposes only.

The No. 4 set is used both as a balancer and as a motor generator. The high-tension side consists of a synchronous motor which drives two compound-wound generators. The total capacity of the two direct-current generators is 150 kilowatts.

The engine of No. 6 set, of 1,400 horsepower, is of the marine type, with Corliss valves and Whitehead governor for normal working at 100 revolutions per minute. When the speed exceeds 115 revolutions per minute, an Aspinall emergency-governor comes into play. The cylinders of this engine are 17½, 28½ and 48 inches in diameter respectively, and 3 feet stroke. The specified variation from normal speed when the load is thrown off is 5 per cent., the normal variation was specified not to exceed 2 per cent., and at the official trials the variation in speed was within the limits named. The generator, of 750 kilowatts, is wound so as to give 2,500 volts (the original working pressure), or 5,500 volts, at a periodicity of 40 cycles per second. The armature is built of soft grade sheet-iron, and is ventilated by means of spaces, which allow a free circulation of air in contact with the winding. The form-wound armature-coils are laid in slots, of which there is one pole per phase. The pole-pieces are built up of high permeability punchings. The field-winding consists of copper strips, the magnets being excited at 240 volts. The efficiency is 95 per cent. at full load, and 91½ per cent. at half load. All the three-phase machines are star-wound, with the middle point earthed.

For Nos. 7, 8 and 9 sets, the engines (1,400 horsepower each) have four cylinders each, 19, 31, 34 and 34 inches in diameter and 3 feet stroke. The four cranks are not set exactly at right angles, the engines being specially balanced on the Yarrow-Schlich-Tweedy system. These engines are furnished with Stumpf fly-wheel type governors. The generators coupled to the engines are precisely similar to that driven by No. 6 engine.

The No. 10 set consists of a Parsons turbine, coupled direct to a 1,500 kilowatts generator. The turbine is one of the largest yet manufactured, and the steam expands uniformly from 200 pounds to vacuum-pressure. It is provided with the Parsons mechanical governor for normal running, and also with a centrifugal-type governor designed to shut off steam when the turbine attains a speed 20 per cent. greater than its normal rate. The condenser and the air-pump are situated immediately below

the turbine. The Parsons air-pump is capable of producing a vacuum of 29 inches. The exhaust-pipe is 36 inches in diameter, a size necessitated by the unusually low pressure of the exhaust-steam. The bearings are of white metal, with forced lubrication. In a recent test of this set, the amount of steam used per kilowatt per hour was found to be 17·8 pounds: a figure which compares most favourably with engines of the reciprocating type. The generator, unlike all the other high-tension machines in the station, has a revolving armature with fixed fields. The collector-rings are insulated from the wooden sleeve which carries them, by means of mica. It has been found that hunting of the synchronous motors at the sub-stations is less pronounced when these are worked from the turbo-alternator than from the reciprocating sets.

Switchboards.—On the high-tension switchboards, all the main feeder switches have oil-breaks, and the remainder break in air. The board is furnished with the usual synchronizing gear in duplicate, also wattmeters and ammeters. Below the high-tension switches are the field-switches, provided with carbon-breaks; also the hand-wheels for regulating the field-resistances. A subsidiary switchboard is erected in a building on the northern side of the power-house. The main high-tension feeders, which are coupled up to this board, are furnished with spark-gaps, connected across the cores. Their object is to allow a discharge to take place, in the event of the normal voltage being exceeded from any accidental cause.

The low-tension switchboard is provided with three sets of omnibus-bars, one set is in connection with the low-tension network, one set is used for exciting purposes, and the remaining set is used to supply the station lighting and power. In addition to this main board, there are two sets of low-tension panels situated beneath the gallery. These are respectively for the equalizing and starting switches, and for the low-tension meters. Behind the board, are the lighting arresters in connection with the overhead line.

Sub-stations.—There are four principal sub-stations in the Newcastle-upon-Tyne area, in addition to one at Wallsend owned by the Walker and Wallsend Union Gas Company. Besides

these, each of the large manufacturers has a sub-station containing static transformers and high-tension switchgear.

In the Manors sub-station, which is a typical example of these buildings, there are installed two 500 kilowatts motor-generators, one 75 kilowatts induction-motor generator, used for starting the large synchronous sets and one 25 kilowatts balancer. The switches, which are situate in the basement of the building, break in oil, and are so arranged that they can be manipulated from above, thus obviating the necessity of having high-tension connections on the gallery. The high-tension switchboard is furnished with synchronizing lamps and voltmeters, connected to transformers in the usual manner. In addition to the voltmeters and ammeters, there is an indicating kilowatt-meter and a direct-reading power-factor indicator. There are also two induction-meters for measuring the units supplied to the station. All these instruments are connected to transformers placed in the basement. The low-tension switchboard is arranged with the positive and negative panels placed on either side of the central neutral panels. On the back of each set of panels, three omnibus-bars are mounted, any one of which can, by means of the plugs and switches in front of the board, be connected to any feeder or generator. Below the low-tension switchboard on the ground level are the field-switches and the main-generator fuse. The sub-stations are all interconnected by special cables, so that any portion of the network can be supplied to any sub-station.

The station at Pandon Dene, which previous to the completion of the transmission line from Wallsend was used as a generating-station, is now being converted into a sub-station with motor-generators similar to those in use at the Manors.

APPENDICES.

I.—NOTES OF PAPERS ON THE WORKING OF MINES, METALLURGY, ETC., FROM THE TRANSACTIONS OF COLONIAL AND FOREIGN SOCIETIES AND COLONIAL AND FOREIGN PUBLICATIONS.

THE FORMATION OF COAL.

Sur la Transformation des Végétaux en Combustibles Fossiles. *By* L. LEMIÈRE. *Comptes-rendus du huitième Congrès géologique international*, 1900 [1901], *pages* 502-520.

The author's main purpose is to show that there is complete analogy between the several phases of the manufacture of alcohol and those of the formation of coal, and, after marshalling in some detail the evidence which goes to support this assertion, he tabulates his conclusions much as follows:—

The principal factors in the transformation of plant-remains into fossil fuel are soluble ferments, living ferments, and antiseptic substances. The soluble ferments are not perhaps indispensable for the purpose of bringing about a certain degree of carbonization (they do not play much part, for instance, in the formation of peat); but when they are present they activate the process of maceration, that is the formation of the "fundamental pulp." The living ferments are the active agents of carbonization, while the antiseptic substances are necessary checks to gasification, and thereby save from complete destruction some portion of the vegetable mass.

Living ferments produced their maximum effect in the formation of anthracite, since that mineral contains as much as 95 per cent. of carbon. Soluble ferments give to ordinary coal its predominant characteristics: the formation of boghead and cannel-coals and of bitumens generally is traceable to the abundant supply of "vegetable jelly." In the case of lignites, the predominance of the several factors varied—sometimes the one, sometimes the other had the upper hand; and occasionally the antiseptic nature of the environing medium plays a considerable part, as in the case of xyloid lignites formed in sea-water. In peat-mosses, living ferments are abundant, but their action is rapidly modified by their own antiseptic products: apparently, soluble ferments are absent. Generally speaking, the formation of coal proper may be described as a diastasic and microbian process: the action of diastase corresponding to maceration, and the action properly so-called of the microbes corresponding to fermentation. The differences between natural fuels are assignable in part to the variety of vegetable secretions, and mainly to the varying proportions of the three factors already enumerated (soluble and living ferments and antiseptic substances). The amount of volatile matter present in a coal has nothing to do with its depth below the surface or with pressure, but depends on the nature of the plants and the microbes concerned in its formation. Similarly

the gases exuded from coal (fire-damp, carbon dioxide, etc.) are dependent on the same factors, but it is true that their retention within the seam or within its roof is conditioned by the more or less complete impermeability of, and the amount of pressure exerted by, the superincumbent strata.

There is no occasion for supposing that the plant-remains, before being buried beneath other deposits, underwent any other physical or chemical action than that which might take place as they were drifted along, for they brought with them all the factors necessary for their metamorphosis. Coal, then, need not have been formed before it was buried—in fact, it attained its definite chemical composition after the plant-remains of which it was made up were incorporated with other sediments. There is no question of considerable pressure, or of temperatures rising much higher than 140° Fahr.

Finally, each variety of fuel reaches a stationary condition at a certain point, at a time when the diastasic action is exhausted and the microbes have ceased to be. Save the intervention of external forces, peat arrived at its last stage will remain for ever peat; lignites will never become coal; nor coal anthracite. The plant-remains have passed from the vegetable into the mineral kingdom; time has accomplished its work, and in presence alone of inert matter embedded in a mass of other sedimentary deposits, it can never again exert any modifying influence, however long we may suppose time to last.

At all epochs, the determining course of the metamorphosis of plants into fossil fuel, the action of ferments on cellulose, has remained the same. Its "modality" alone varied through the ages (by which the author appears also to mean that the anthracite-producing microbe differed from the cannel-producing microbe, and so on). We may observe, however, that the author does admit that certain anthracites are metamorphosed coals.

L. L. B.

COAL-FORMING BACTERIACEÆ.

Du Rôle de quelques Bactériacées Fossiles au Point de Vue géologique. By B. Renault. *Comptes-rendus du huitième Congrès géologique international*, 1900 [1901], *pages* 646-663, *with* 13 *figures in the text and plates* vii. *to* ix.

Most of the recent forms of Bacteriaceæ—*Micrococcus*, *Bacillus*, *Streptococcus*, and *Streptothrix*—have been found in the fossil state at various geological horizons, in such animal and vegetable tissues as underwent mineralization before they had been very long exposed to the action of water and air.

The author describes and figures, as samples of the organisms preserved by silification, spherical masses of *Micrococcus* found in the pith of *Arthropitus* (an Upper Coal-measure plant), and various species of *Bacillus* occurring in *Pecopteris* and other ferns from the St. Étienne Coal-measures. The microscopic evidence leads him to infer that silicifying waters must have invaded the Coal-measure swamps or peat-mosses, and arrested the microbic decomposition of the plant-remains, which would otherwise have been completely destroyed.

Premising that boghead coals are the outcome of the accumulation of freshwater algæ at the bottom of small lakes, during periods ranging from the Culm to the Permian, the author points out that the species of the algæ, and sometimes the genus, varies according to the stratigraphical horizon and the geographical position. Thus, by mere inspection of a slide

under the microscope, he is able to determine whether a boghead comes from Autun or Kentucky, from Moscow or Armadale. The algæ were largely decomposed by the bacterial action of *Micrococcus petrolei*. The transformation of cellulose into boghead may be chemically defined as a practically-complete deoxidizing and partially dehydrating process:—

$$C_{12}H_{20}O_{10} = 2(C_2H_3) + 5CO_2 + 3CH_4 + 2H$$

Cellulose. Boghead. Carbon dioxide. Methane. Hydrogen.

Cannel-coals, on the other hand, are not simply (or mostly) made up of the remains of algæ, but more largely of the sporangia, etc., of club-mosses and ferns. Under the microscope they are seen to be permeated with myriads of *Micrococci*. The algæ vary from place to place, as in the case of the boghead coals.

Descriptions and figures are also given of the Bacteriaceæ which played so large a part in the formation of ordinary coal. It is reckoned that four-fifths of the original volume of cellulose was thus got rid of in the form of gases, while the remaining fifth represents the amount of coal formed. The process is expressed by the chemical equation:—

$$4(C_{12}H_{20}O_{10}) = 2(C_9H_6O) + 14(CH_4) + 16CO_2 + 6H_2O$$

Cellulose. Coal. Methane. Carbon dioxide. Water.

The author states that the foregoing formula for typical coal applies to a pure coal, whereas, of course, in many cases the gases of fermentation are in part still occluded by capillary attraction, etc., within the coal. He figures a microscope-section showing gas-cavities with contiguous masses of *Micrococcus* and *Bacillus* in coal, as illustrating this point.

He emphasizes in his conclusions the importance of the part played by Bacteriaceæ in the formation of coal, lignite, and peat, and draws once more attention to the fact that the nature of the vegetable matter operated on by the microbes has much to do with the quality of the fossil fuel produced.

The interest of the paper is much enhanced by the admirable illustrations which accompany it. L. L. B.

HUMIC AND OTHER COALS.

Charbons gélosiques et Charbons humiques. *By* C. E. BERTRAND. *Comptes-rendus du huitième Congrès géologique international*, 1900 [1901], *pages* 458-497.

The author is engaged on a series of detailed studies on fossil fuel of all kinds, but in this elaborate memoir he deals only with those types the history of which he believes to have worked out completely.

Under the heading of *gelosic coals* (coals of the "jelly" type) he classifies the kerosene-shales of New South Wales, the boghead coal of Autun, and the Torbane Hill mineral. The former two have been the subject of very complete monographs, but the last-named, he says, still awaits its monographer.

These three types result from the accumulation of algæ in a humic brown "jelly." He postulates further that the algæ were accumulated very rapidly, and that the fossilization of the jelly-like mass took place in the presence of bitumen. He gives a lengthy description of the structure and mode of formation of the Autun boghead and the kerosene-shale,

and then proceeds to deal with what he terms *humic coals*. As types of these he selects the Broxburn oil-shale, the Tertiary shale of Bois d'Asson (Basses Alpes), and the Cretaceous shale of Ceara in Brazil. He applies to bituminous shales the appellation of "humic coal" so long as the organic matter so predominates over the mineral matter as to give the "coal" its characteristic properties. He postulates that this kind of coal is formed from accumulations of brown "jelly," with which was associated a small quantity of spores, pollen, thalli of algæ, etc. (to the extent of about 4 parts in 10,000), and that the fossilization of this also took place in the presence of bitumen. In all cases, he considers that bitumen accounts for the occurrence of lamellæ of bright coal among bogheads and shales. Humic coals are the type of truly amorphous coal: they have a shale-like aspect, because their "fundamental jelly," readily combining with argillaceous matter, happened to be in contact with a sufficient quantity of such matter. Although he fully recognizes the importance of bacterial action in the case of *gelosic coals*, there does not seem to be any trace of the presence of Bacteriaceæ in the case of *humic coals*. Finally, he classes as *charbon de purin*, or *excretory coal* the bituminous shale of the Allier, which consists of a "coagulated brown jelly fossilized in the presence of bitumen." But in this case the brown "mother-liquor" was highly charged with excretory or stercorary substances. Reptilian coprolites occur abundantly in this shale, and associated with them are nodules of animal charcoal. Microscopic examination discloses the presence in this "excretory coal" of masses of bacteriform bodies, as also vegetable spores and pollen.

L. L. B.

BOGHEAD COALS FORMED FROM ALGÆ.

Sur quelques Algues Fossiles des Terrains anciens. By B. RENAULT. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences*, 1903, *vol. cxxxvi., pages* 1340-1343, *with* 6 *figures in the text.*

All the boghead coals that the author has examined are made up of the bedded accumulations of algæ, the structure of which is well preserved.

The Autun boghead is made up of a globulous alga, *Pila*, a genus of which many species have been described by the author, characteristic of the Northern Hemisphere. The genus *Reinschia*, on the other hand, is characteristic of the Southern Hemisphere, and it is of species belonging to this genus that the Australian and Transvaal bogheads are made up.

The Armadale boghead is chiefly built up from the agglomeration of the thalli of an alga, which the author calls *Thylax Britannicus*, very diminutive in comparison with the genera mentioned in the preceding paragraph.

The bogheads of the Moscow basin are built up of a highly ramified alga, to which the author applies the generic designation of *Cladiscothallus*. The same genus is found in the North American bogheads.

The author maintains that each important deposit of boghead coal is recognizable or distinguishable by means of the particular genus of alga from which it is derived, and that the invariable presence of Bacteriaceæ on the walls of the cells of the algæ leads inevitably to the inference that these bacteria (*Micrococcus petrolei*) setting up a special fermentation, played an important part in the transformation of the cellulose of the algæ into fossil mineral fuel.

L. L. B.

FISSURE-VEINS.

Metasomatic Processes in Fissure-veins. *By* WALDEMAR LINDGREN. *Transaction of the American Institute of Mining Engineers, 1900, vol. xxx., pages 578-692.*

The following is an abstract of the conclusions presented in this paper:— Almost all fissure-veins are bordered by altered zones of varying extent and intensity of alteration. In replacement-veins, this altered rock contains the valuable ore.

Metasomatic processes vary in different classes of veins, quartz may be converted into calcite in one class, while calcite may be converted into quartz in another; the action is usually intense, and the chemical composition much changed. The hydration connected with the alteration is only very moderate. Potash-mica in some form is the most prominent mineral formed by the metasomatic processes: the most prominent process being the progressive elimination of soda and concentration of potash. Metasomatic processes in fissure-veins differ distinctly in most cases from those involved in static, dynamic and contact metamorphism; the two classes of change have not generally taken place under the same conditions and agencies; there are, however, some exceptions. Ordinarily, the alteration consists in the total or partial loss of some constituents; the gain of others; and the introduction of new compounds and elements, usually carbon dioxide and sulphur. The result may be a gain, or loss, per unit of weight or volume.

The processes observed can, generally, only be explained by aqueous agencies. The intensity shows that the aqueous solutions acted under moderately high temperature, pressure and concentration; no cold pure surface-water could have produced such results as are ordinarily found.

Since the substances introduced are only known to be contained in noteworthy quantities in thermal waters ascending through fissures, it is concluded that these waters were the active agencies in the process of alteration. Many of the substances found filling the open spaces along the fissure may be lacking in the altered rock, showing that the latter is not as easily penetrated by all the constitutents of the solution.

The ascending waters are chiefly surface-waters, which, after a circuitous route underground, have found, in a fissure, an easy path by which to return. During their downward passage, they dissolve material from the rocks which they penetrate, their power to dissolve being increased by the heat and pressure due to the depth. During the ascending period, much of this material is deposited. The metasomatic action on the wall-rock causes further exchanges of constituents, some being dissolved and others deposited.

Probably most fissure-veins are genetically connected with intrusive rocks, even when the deposits are contained in the overlying surface-lavas. Intrusive rocks may contain carbon dioxide, water, sulphur, etc., at the time of their intrusion. Under decreasing pressure, these substances tend to leave the cooling magma; and as many of them form, with the heavy metals also contained in the magma, volatile compounds with a low critical temperature, these heavy metals may be carried away from the magma along with the mineralizing agents mentioned above. The result of these emanations is seen in contact-metamorphism and in the mineral deposits so often appearing near the boundaries of intrusive bodies. Where fissures traverse the cooling magmas, and the rocks surrounding them, it is natural that these mineralizing agents carrying their load of heavy metals should

ascend above the critical temperature, and on reaching the zone of circulating atmospheric waters it is natural that they should mix with them. To this combination of agencies, found in the ascending waters of such regions of igneous intrusion, the formation of most metalliferous veins is probably due. Some classes of veins may be due to circulating surface-waters alone; but it is incredible that the dissolving power of the latter is sufficient to account for all classes, or even for the majority, of fissure-veins.

A. W. G.

ORE-DEPOSITS.

Origin and Classification of Ore-deposits. *By* CHARLES R. KEYES. *Transactions of the American Institute of Mining Engineers*, 1900, *vol. xxx., pages* 323-356.

The accompanying scheme tabulates the groups and categories of ore-deposition with the general forms of ore-bodies recognized by miners:—

Groups.	Categories.	Miners' Forms.
I. Hypotaxic: mainly surface deposits.	Aqueous transportation.	Placers.
	Residual cumulation.	Pockets (in part).
	Precipitative action.	Bog-bodies, some beds, layers.
II. Eutaxic: chiefly stratified formations.	Original sedimentation.	Beds, strata, layers.
	Selective dissemination.	Impregnations (in part).
	Emponded amassment.	Masses (in part), some segregations.
	Fold-filling.	Saddle-reefs.
	Crevice accretion.	Gash-veins, stockworks (in part).
	Concretionary accumulation	Nodules.
	Metamorphic replacement.	Fahlbands (in part), beds.
III. Ataxic: predominantly unstratified and irregular bodies.	Magmatic secretion.	Masses (in part), some lenses.
	Metamorphic segregation.	Stocks, lenses.
	Fumerole-impregnation.	Contact-veins.
	Preferential collection.	Chambers (in part), some pockets, linked-veins.
	Fissure-occupation.	Attrition-veins, true veins, some linked-veins.

A. W. G.

THE PART PLAYED BY TITANIUM IN MINERAL-DEPOSITS.

Le Rôle du Titane en Geologie. *By* L. DE LAUNAY. *Annales des Mines*, 1903, *series* 10, *vol. iii., pages* 86-105, *with* 2 *figures in the text.*

Pointing out, first of all, two essential facts which characterize the chemical properties of titanium, namely, its analogy on the one hand, with iron; and, on the other, with the group of silicon, tin, zircon and carbon, the author proceeds to consider the most important occurrences of the metal. Hundreds of deposits of titaniferous iron-ore are known in Scandinavia, Finland, Canada and the United States, and Brazil. These all occur as masses in the midst of basic igneous rocks, mostly gabbros: three only

being in nepheline-syenites, those of Alnö, São Paulo, and Magnet Cove (Arkansas). As a general rule, where ferruginous segregations do occur in acidic rocks, titanium is all but absent. On the other hand, it will be observed that chrome-iron-ore and platinum are the characteristic metalliferous occurrences in peridotites. In these the olivine is generally of later crystallization than the chrome-iron-ore, whereas the titaniferous ore, in the rocks where it occurs, encases the other constituents, showing that it was of later consolidation than they.

Viewing eruptive rocks as a whole, they generally contain about 0·32 per cent of titanium compared with 4·5 per cent. of iron; but in gabbros, the titanium has consolidated faster than the iron, and the comparative proportion increases to 1 in 10 or 12; in titaniferous iron-ores the proportion is 1 to 5 or 7·5.

Postulating that one of the essential phenomena of vulcanicity, however deep-seated, is the introduction of surface-waters by means of the dislocations brought about by folding of the earth's crust, the author considers that this water acting on the carbon, which is most probably one of the fundamental elements of the deep-lying magma, has given rise to hydrogen carbides, and these in turn to carbonic acid, which, either free or associated with alkalies, has been the essential agent in the formation of many of the minerals characteristic of metalliferous veins.

Some little space is devoted to the consideration of titanium-minerals in acid rocks, but it does not appear that these are of great economic importance. L. L. B.

EXPERIMENTS ON THE PERMEABILITY OF CLAY.

Quelques Expériences sur la Perméabilité de l'Argile. By W. SPRING. *Annales de la Société géologique de Belgique*, 1901, *vol. xxviii., Mémoires, pages* 117-127.

The author set himself out to determine experimentally under what conditions water will pass through a stratum of clay, and whether this passage is possible in nature. He took plastic grey clay from Andenne, which contains very little sandy matter: in the completely dry state this clay has a specific gravity of 2·62, but when it has been kneaded up with 17 per cent. of water, its specific gravity is only 2·05—that is, the volume of clay is simply increased by the volume of water added to it. The question then arises whether the swelling of the clay is not a necessary condition, as well as a consequence, of the penetration of water; in other words, whether a clay mechanically prevented from expanding would be permeable to water. The author then proved by experiment that a mass of clay, which was allowed to expand freely, absorbed about seven times as much water as a similar mass of clay, which was prevented from expanding: in other words, 15·65 per cent. as compared with 2·67 per cent.

On the other hand, he ascertained that a mass of clay kneaded up with 33 per cent. of water could, if sufficiently compressed, be made to yield up a large quantity of the contained water, even if kept under water. He made use of a piston which exercised a pressure of about 42 pounds per square inch (3 kilogrammes per square centimetre) during three days, and at the end of that time it was found that the clay had given up 30 per cent. of the contained water. Then the experiments were varied, by making the clay more and more watery, till about 70 per cent. of its total volume

was water; but, however the proportion was varied, the quantity finally retained by the clay after compression was practically the same in all cases, that is 27 per cent. roughly. On increasing the pressure, however, to as much as three times that above-mentioned, about 4 per cent. more water was eliminated.

The author made further "imbibition-experiments" with gelatine, starch, and loam from the plateau of Hesbaye, and found that all these substances resembled clay in their comparative refractoriness to water-percolation or absorption, if prevented from expanding freely. The proportional percentages are, however, very different.

One conclusion which will appear fairly obvious is, that the deeper a clay-bed lies below the surface, the greater is its state of compression from the superincumbent weight and the more restricted will be the possible range of percolation of water. L. L. B.

SALINE WATERS IN THE FRANCO-BELGIAN COAL-MEASURES.

Sur les Eaux Salines des Nappes Aquifères du Nord de la France. By JULES GOSSELET. *Comptes-rendus du huitième Congrès géologique international*, 1900 [1901], *pages* 383-385.

Many of the deep borings in the north of France yield waters containing sodium chloride (salt) or sodium carbonate, and yet these borings traverse only strata, such as chalk, limestone and sandstones, that contain no sodium-compounds. The presence of sodium appears to be connected, on the whole, though not universally, with the depth of the boring. The question is as to where it comes from: no saliferous Triassic deposits have been struck in this region, and the hypothesis of infiltration from rain-water is also excluded. Two suppositions appear to the author admissible: (1) that we are dealing here with the remnants of the waters of ancient seas; and (2) that water from the present ocean-bed is forced by pressure into the permeable strata underlying it, and then gradually percolates downward.

However that may be, we cannot lose sight of the fact that the waters pumped from the Coal-measures of northern France and Belgium contain sodium in three combinations:—chloride, carbonate and sulphate. The chloride is characteristic of the water which properly belongs to the Coal-measures, and has not been exposed to mixture with water from other sources. The carbonate indicates a mixture of the true Coal-measure waters with those which have percolated down from the surface through the Chalk. The presence of sulphate is traced to the band of pyritous shales, which occurs at the base of the Westphalian series, and is worked around Liége for the manufacture of alum. Consequently, sulphated waters indicate that one is getting near the base of the workable Coal-measures, near limestones which are considerably jointed and hold a large volume of water. Therefore, mining-engineers in the Franco-Belgian coal-field regard waters containing sulphates as carrying with them a sort of warning, and constituting, it may be said, a danger-signal. L. L. B.

THE EARTHQUAKE IN NORTHERN BAKONY, HUNGARY, 1901.

Über das Erdbeben im nördlichen Bakony vom 16. Februar, 1901. *By* Dr. Franz Schafarzik. *Földtani Közlöny*, 1901, *vol. xxxi., pages* 184-186, *with a map in the text.*

This earthquake took place about 5 p.m. on February 16th, 1901, in Northern Bakony, the name given to an area which stretches over part of the two contiguous counties of Veszprém and Györ. The inhabitants were terror-stricken, and yet no serious damage was suffered. The report from Gicz, a village in the epicentral area, states that shortly after 5·17 p.m. on the day mentioned, a violent shock, travelling from north to south, was felt, and lasted about 5 seconds. It was accompanied by loud rumbling, the houses seemed to oscillate, and ominous cracks were heard. The villagers rushed out into the road, in the belief that the roofs were falling in. Chandeliers were set swinging, and so forth; yet no clock was stopped, and no fissures were observed in the house-walls. Similar accounts came in from the farmsteads of Romány, Tamási and Varsány. No premonitory symptoms were shown by birds, domestic animals, etc., and there was nothing abnormal about the weather. One observer, however, states that at 3·15 p.m. a sort of explosive crash was heard, no cause for which can be traced. The violence of the shock at Gicz corresponded to 6 in the De Rossi-Forel scale. Beyond the epicentral area, the earthquake appears to have travelled with greatest facility along a line running from north-north-west to south-south-east, through Zircz, etc. Transverse faults are known to occur in great number in the Bakony basement-rocks (along the northern margin of which the epicentrum lay); and it is probably along one such fault-fissure, which happens to be intercalated among those previously known, that the earthquake found the line of least resistance to its propagation. The origin of the shock is, however, believed to be a tangential rupture defining the north-western margin of the Bakony massif. L. L. B.

EARTHQUAKE IN SOUTHERN HUNGARY, 1901.

Das Erdbeben in Südungarn vom 2. April, 1901. *By* Franz Lajos. *Földtani Közlöny*, 1902, *vol. xxxii., pages* 322-325, *and* 1 *plate.*

About 6 p.m. on April 2nd, 1901, an earthquake took place, the effects of which were felt over about ten counties in Southern Hungary and over a large portion of Servia as well, that is, over an area of some 28,000 square miles. It had been preceded by various premonitory shocks, between March 26th and 31st, and was followed by after-shocks up to April 8th. Records were obtained from observers in 171 different localities.

The earthquake was among the most considerable that had taken place in Hungary since the eleventh century. The area mapped out by the isoseismal curves has an ovoid form, the longer diameter striking north-north-west and south-south-east and measuring about 200 miles; while the shorter diameter runs from east-north-east to west-south-west, and measures some 185 miles. This last is coincident in direction with the major axis of the epicentral area. The epicentral area (952 square miles) is of very irregular form. Within it about 40 buildings were reduced to ruins, and 300 chimneys crashed down. The violence of the shock lay between 6 and 7 degrees on the Forel scale, and its effects were most destructive along the banks of the Béga and Temes rivers. Indeed the original focus of the earthquake is

believed to have lain somewhere below the Béga valley, and here two persons lost their lives.

Outside the epicentral area, lies one of ellipsoidal form, covering some 2,470 square miles, within which some slight damage was done, the violence of the shocks ranging between 5 and 6 degrees of the Forel scale. Outside that again, areas of diminishing seismic intensity are plotted out, and it is noticeable that this intensity decreased far more slowly southward than in any other direction.

The main shock lasted, according to the locality where it was felt, from 1 to 10 seconds, and was accompanied by a subterranean rumbling, variously likened to distant thunder, the rush of a railway-train, the clattering of a heavy-laden dray, etc. The velocity of propagation is reckoned to have been about 1,000 feet per second.

The area affected is largely covered with deposits of loose texture (drifts and alluvia), below these come the Levantine and Pontic formations, and below these again the highly-fractured *massifs* of older rock. A fault-fissure is known to coincide with the strike of the Béga valley, and it is presumed that the earthquake was due to the sagging of rock-masses along this line.

L. L. B.

SEISMIC DISTURBANCES IN BELGIUM IN MAY, 1902.

Sur les Mouvements sismiques et les Perturbations magnétiques du Commencement de Mai, à la Station d'Uccle (Belgique). By EUG. LAGRANGE. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences*, 1902, *vol. cxxxiv., pages* 1325-1327.

The author points out that, on the whole, seismic activity has become more marked on the surface of the globe since the beginning of 1902. He then shows that the Von Rebeur-Ehlert triple horizontal pendulum, set up at the Uccle geophysical observatory in Belgium, registered several considerable earth-tremors in the first fortnight of May (a fortnight which will be rendered ever memorable by the St. Pierre and St. Vincent catastrophes). Thus, on May 6th, shortly after 3·15 a.m., a diphasic disturbance began, the entire duration of which may be reckoned at 40 minutes. It seems to have originated in the depths of the western Mediterranean, off the coast of Spain, and to have travelled at the rate of almost exactly 1 mile per second. Tremors of less consequence had been numerous between May 1st and 6th, while from the 6th to the 8th, there was an interval of absolute quietude. On the 8th, however, at 2·47 a.m., a seismic disturbance far more considerable than any of the preceding made itself felt: the two periods of short and long undulations respectively being well marked, and the former phase lasting for 33 minutes. The general effect was that of an earthquake, the focus of which lay at a great distance. It was possibly connected with the Martinique eruptions, but certainly not with the great outburst of Mont Pelé which overwhelmed St. Pierre at a time equivalent to a few minutes after noon in North-western Europe.

The author has made comparative studies of magnetic perturbations and seismic movements, and so far the results obtained appear to confirm the conclusions of the Krakatoa Commission, that there is no effective association between the two orders of phenomena. L. L. B.

EARTHQUAKES IN BAVARIA.

Beiträge zur Erdbebenkunde von Bayern. By DR. JOSEPH REINDL. *Sitzungsberichte der Mathematisch-physikalischen Klasse der königlichen Bayerischen Akademie der Wissenschaften zu München*, 1903, *pages* 171-204, *with* 3 *figures and a map in the text.*

The author first of all describes the earthquake which took place at about 1·20 p.m. on November 26th, 1902, in the frontier-districts of Bavaria and Bohemia. The shock was recorded by the Wiechert seismometer in the Leipzig observatory, and lasted altogether 1 minute and 52 seconds: the total area over which it was felt measured about 1,545 square miles. In the area where it reached its greatest intensity, this is estimated to have corresponded to 5 in the De Rossi scale or 6 in the Forel scale. Houses quaked, church-bells were set ringing, mortar fell from the walls, objects placed on tables, benches and stoves tumbled down, and some walls were cracked. Prof. Credner believes that the seismic phenomena extended in reality over a greater area than that above mentioned. The direction of the shock was apparently from south-west to north-east, and the cause is attributed to tectonic movements in the highly-faulted complex of rocks of which that portion of the earth's crust consists.

The author then gives a catalogue of earthquakes in Bavaria, from 1008 A.D. up to 1903, supplementing the catalogue drawn up by the late Prof. Von Gümbel. Thereupon follows a description of the earthquake which occurred on January 25th, 26th and 27th, 1903, in the Bavarian Palatinate. The epicentrum lay somewhere below the village of Kandel. On the first day (Sunday, 25th) three violent shocks were felt at 9·45 a.m., 1 p.m. and 3·15 p.m. respectively; four on the second day, at 12·30 a.m., 7 a.m., 7·5 a.m. and 4 p.m. respectively; and three on the morning of the third day: they were accompanied by a rumbling as of thunder. No damage of any importance was occasioned by these shocks, but they caused much disquiet among the villagers and the stalled cattle. The direction of travel of the earthquake was from south-west to north-east, and its determining cause is no doubt to be sought in sagging movements connected with the great Rhenish Rift and the associated fault-fissures.

On March 22nd, 1903, the luckless village of Kandel was again the epicentral locality of one of the most considerable earthquakes that has ever occurred in the Palatinate. A premonitory shock was felt at 7·45 p.m. on March 21st; this was followed the next morning and afternoon by five violent shocks: chimneys crashed down, walls and ceilings were fissured, and a shower of plaster fell from them. The undulatory motion of floors and walls was very perceptible to the eye. After-shocks were observed on March 26th and 27th. The duration of the principal shock can hardly have exceeded 4 seconds. Signs of great fear were shown by all domestic animals. It is noteworthy that earth-tremors were recorded at the same time in Italy, the South of France, and the South of England, and that the Soufrière of St. Vincent was again erupting.

An extensive tract of North-eastern Bavaria was involved in the earthquakes which took place in the mountains of the Erzgebirge, Fichtelgebirge and the neighbouring Bohemian Forest on March 5th and 6th, 1903. Preliminary tremors had been observed on and about February 20th. The epicentral locality was Asch, a Bohemian town close to the Bavarian frontier: here seven violent shocks occurred on the morning and evening of March 5th, and the morning and afternoon of the next day. People ran in terror from their houses into the streets, chimneys fell down, cracks opened up in the walls, the electric light went out in many buildings. The intensity was

reckoned as 7 in the Forel scale at Asch, and as 6 in several other localities. The general direction of travel was from south-west to north-east, and the cause is attributed to tectonic movements taking place in the highly-faulted and fissured rocks of that area. It is, indeed, a region which has been over and over again visited by earthquakes.

Dr. Knett considers the last-described earthquake as belonging to one of the periodic "earthquake-swarms," caused by the pressures acting from the Alps in the south-east on the Bohemian *massif*: the Erzgebirge plays the part of a sort of seismic accumulator, and once a certain limit of tension is reached these accumulated pressures are released in the form of earthquake-swarms. The next batch should have been looked for, on this hypothesis, between the years 1950 and 1975, but the complication introduced by the "swarms" of 1900 and 1901 leads to the conclusion that a depression is gradually forming, transverse to the strike of the Erzgebirge, the full effects of which may not be felt for thousands of years to come. L. L. B.

"EARTHQUAKE-SWARMS" IN SAXONY AND BOHEMIA, 1900-1902.

Die Vogtländischen Erderschütterungen in dem Zeitraume vom September, 1900, *bis zum März*, 1902, *insbesondere die Erdbebenschwärme im Frühjahr und Sommer*, 1901. *By* HERMANN CREDNER. *Berichte der Mathematisch-physischen Classe der königlichen Sächsischen Gesellschaft der Wissenschaften zu Leipzig*, 1902, *pages* 74-90, *with two maps in the text.*

After a brief description of the earth-tremors recorded at various localities in the Vogtland (Saxony) between September 19th, 1900, and February 13th, 1901, the author proceeds to consider the "earthquake-swarms," consisting of not less and perhaps more than 106 separate shocks, which visited the southern portion of that district between May 8th and June 28th, 1901. The most violent shock was felt on June 2nd at Brambach and Schönberg: the ground appeared to heave and sink, windows clattered, the birds flew in alarm out of their nests, and a noise like thunder accompanied the shock. This "subterranean thunder" was a characteristic accompaniment of many of the other tremors.

Only a few weeks of tranquillity intervened before another "earthquake-swarm" visited the same district, but extended this time into the Egerland (Bohemia). It began with a fairly violent shock at 1·50 p.m. on July 25th, 1901, of seismicity 5 in the earthquake-scale, travelling from north-west to south-east. The heaving of the soil, the quaking of walls, the clattering of windows, and the displacement of small articles of furniture were reported from the whole of the epicentral area. About 15 after-shocks were recorded up to the afternoon of August 31st. Then, for a period of several months, there was complete tranquillity, broken on December 8th and 9th by two very sharp shocks accompanied by a roar like thunder. These were recorded at Markneukirchen on the 8th at 10·45 p.m. and on the 9th at 5 a.m.

It is characteristic of the earthquakes that have befallen the Vogtland of late years that they occur so frequently in "swarms." Further, that the epicentra, instead of lying in the central and northern districts broken up by the most complicated tectonic disturbances, are situated in the southern district which is comparatively untouched by faulting and folding. In this district two independent foci are recognized: (1) that of Brambach-Schonberg; and (2) the other, that of Graslitz-Untersachsenberg; and the epicentral areas are situated either on granite or on the slates which abut directly on the granite. L. L. B.

THE EARTHQUAKE AT SALÓ, NORTHERN ITALY, 1901.

Sulle Condizioni geognostiche del Territorio di Salò (Prov. di Brescia) rispetto al Terremoto del 30 Ottobre, 1901. *By* L. BALDACCI *and* A. STELLA. *Bollettino del Reale Comitato Geologico d'Italia*, 1902, *vol. xxxiii., pages* 4-25, *and* 3 *plates.*

The authors made a careful examination of the geological structure of the district of Saló, a town which lies on the shores of the Lake of Garda, in the province of Brescia, with the view of determining to how great an extent this structure was a factor in the earthquake which took place there on October 30th, 1901, at 3·48 p.m. The region is subject to fairly-frequent seismic disturbances, but the shock just mentioned is said to be the most violent known to history on the "Riveria Bresciana." The earthquake was preceded by a rumbling as of thunder, and the motion, at first up-and-down, became undulatory, travelling in a direction from south-east to north-west, the duration being 7 seconds. No less than 16 after-shocks followed, the latest on January 9th, 1902, when the authors themselves were staying in the district. Scarcely a single building escaped damage, the greatest havoc being wrought in the flat strip along the lake-shore where the edifices, public and private, for some distance were ruined beyond repair. Half-way up the hillside the damage is considerably less, and it turns out in fact to bear a distinct ratio to the stability or instability of the deposits on which the city and suburbs are built, as well as to the solidity of the buildings themselves. The intensity of the earthquake was hardly so great as the destruction wrought by it would seem to imply, the authors estimating it at somewhat less than 8 in the De Rossi-Forel scale.

The strip along the lake-shore consists of fluvio-glacial deposits; overlying these, and forming the subsoil of the higher part of the city and immediate suburbs, are Quaternary argillaceous drifts. (It will be observed that all these deposits are practically loose detritus.) The solid rock-ridge behind consists of calcareous shales and conglomerates of respectively Cretaceous and Miocene age. Upon this ridge is perched the hamlet of San Bartolomeo, built on a patch of fossiliferous Pliocene clays, and the flanks of the ridge are mantled by a loose rubble of weathered rock. L. L. B.

THE EARTHQUAKES OF GREIZ AND THE BÖHMERWALD, 1902.

Die vom Wiechert'schen astatischen Pendelseismometer der Erdbebenstation Leipzig während des Jahres 1902 *registrirten Nahbeben. By* H. CREDNER. *Berichte der Mathematisch-physischen Klasse der königlichen Sächsischen Gesellschaft der Wissenschaften zu Leipzig*, 1903, 21 *pages*, 1 *plate, and* 3 *text-figures.*

On May 1st, 1902, at Greiz, in the Vogtland district of Saxony, an earthquake took place, the microseismic undulations of which travelled northward beyond Leipzig, and were recorded by the Wiechert astatic pendulum-seismometer in that city. The starting-point of the phenomenon appears to have lain in the highly-disturbed and faulted older Palæozoic belt which trends north-eastward through Zeulenroda, Greiz, and Berga from Pausa-Schleiz, finally disappearing below the Rothliegende formation of the Erzgebirge basin and the Gera district. The seismic phenomena manifested themselves along the strike of this older Palæozoic belt south-westward, but more especially north-eastward, dying out finally on the further side

of the Pleisse valley. The area thus affected was roughly elliptical, with a major axis about 19 miles in length, and a minor axis running east and west, about 12½ miles long—say, in all, 181 square miles. A fairly violent shock, accompanied by a rumbling like thunder, alarmed the inhabitants of Greiz about 5·31 a.m. Doors and windows rattled, houses quaked, and tardy sleepers were all but shaken out of their beds. A second and a third shock followed, of diminishing intensity and shorter duration, as compared with the first. Judging from the record obtained by means of the Wiechert seismometer, the entire duration of the phenomenon does not seem to have exceeded 30 seconds, and no ascertainable damage was done to persons or property.

After discussing at some length the records obtained with the above-mentioned instrument, the author proceeds to describe the earthquake which took place early in the afternoon of November 26th, 1902, in the Böhmerwald (or Great Bohemian Forest) district. The roughly elliptical area affected by this earthquake extends over some 1,544 square miles, the major axis (about 56 miles in length) lying parallel to the main mountain-range. The epicentral area lies in the gneiss and granite-massif of the Böhmerwald, but the geological map fails to reveal any important fault-fissures or dislocations hereabouts, with which the seismic phenomena might be genetically associated. The exact time at which the tremor began was 1·19 p.m., and it reached an intensity (in the pleistoseismic area) of 5 in the De Rossi scale. Bricks fell from chimney-stacks, walls were cracked, houses quaked from roof to basement, doors flew open; in some places people ran out into the streets, and all domestic animals showed signs of great terror. Only one shock is reported in this area, and it was accompanied by a thunderous roar. Farther away from the epicentrum, instead of one shock, the records tell of 2, 3, or 4 undulating tremors lasting several seconds each, and of sufficient violence to give rise to considerable alarm. The entire duration of the phenomenon, as registered by the Wiechert seismometer, was little short of two minutes. L. L. B.

SEISMIC DISTURBANCES IN GREECE DURING 1899.

Résultats des Observations sismiques, faites en Grèce pendant l'Année **1899**. *By* D. Eginitis. *Annales de l'Observatoire National d'Athènes*, **1901**, *vol. iii., pages* 21-27.

The number of earth-tremors recorded in Greece during the year 1899 was 567, exceeding the annual average by 36. This annual average is calculated from the records obtained during the quinquennial period 1893-1898. The frequency of the earth-tremors varied considerably from month to month, the maximum of 119 being observed in March and the minimum of 18 in December. The seasonal variation in number was as follows: 149 shocks in the winter, 271 in the spring, 62 in the summer, and 85 in the autumn. Out of the total 567 shocks, 348 took place during the night and 219 during the day. The records of 1899 confirm the conclusion drawn by the author from the observations made in 1893-1898, that there is no tangible relation between the frequency of seismic disturbances and the position of the moon in its orbit. The same remark holds good in regard to seismic phenomena and the periods of aphelion and perihelion.

A full list is given of the districts and towns or villages where the above-mentioned 567 shocks were observed. Zante would appear to be especially

"favoured" in this respect, no less than 421 out of the total number having been recorded there.

On the morning of January 22nd, 1899, at 12 minutes to 10, the province of Triphylia, on the western coast of Peloponnesus, was visited by an earthquake, which caused a considerable amount of damage, although its effects were, comparatively speaking, local. In the epicentral area at Cyparissia alone 53 houses crashed down, 70 others were rendered uninhabitable, and not a single house escaped damage. The phenomenon consisted of two violent shocks, both of which were preceded and accompanied by a subterranean rumbling. The second, instead of being undulatory in character, as was the first, was jerky in character, and was the one that caused most of the material damage. Each shock lasted about 7 seconds. The direction of travel was from south-west to north-east, almost perpendicular to the major axis of the epicentral ellipse. After-shocks continued for a week after the principal phenomenon. Domestic animals, such as dogs and chickens, showed signs of fear before the earthquake took place, uttering cries of alarm and seeking safety in flight. Prof. Milne's record of the shock, as observed by means of his instruments at Shide, in the Isle of Wight, showed that it travelled thither at the rate of 1¼ miles per second. There were no crevices or fissures opened up in the ground within the epicentral area, although subsidences, which compromised the stability of the railway-line, took place at Calamata. As usual, springs were variously affected in different localities, some drying up, others becoming turbid or flowing in greater volume. The complete "earthquake-catalogue" for 1899, in Greece, on which the author's memoir is based, occupies pages 336 to 375 of the *Annales*.

L. L. B.

THE EARTHQUAKE AT MIGNANO, ITALY, 1902.

Il Terremoto di Mignano (Giugno-Luglio, 1902). *By* V. SABATINI. *Bollettino del Reale Comitato Geologico d'Italia, 1902, vol. xxxiii., pages 178-198, and 1 plate.*

This memoir embodies the results of the investigation conducted on the spot by the author, at the request of the Minister of the Interior. The buildings at Mignano are generally of such poor materials and so execrably put together, that the very fact that they have not been reduced to a heap of ruins by a succession of earth-tremors extending over forty days or so, shows (in the author's opinion) that those tremors cannot have been of a very serious character. The motion, too, must have been mainly "up and down," rather than undulatory.

The first plainly perceptible shock was felt at 7·30 a.m. on June 24th, 1902, and another followed about 11 a.m. After an interval of several days of complete quietude, there came a series of after-shocks, from two or three to six or seven in a day, generally between 10 and 11 a.m., then at 11 p.m., and finally between 1 and 2 a.m. It is stated (whatever that may mean) that "the strongest shocks were generally felt on the night which followed on a Sunday!"

About July 4th or 5th, thunderous subterranean rumblings began to be heard, sometimes associated with earthquake-shocks, sometimes not. The inhabitants were panic-stricken on the night of Sunday, July 20th, when the earthquake-roar is described as unceasing and the shocks as continuous. About a week later, at 1·3 a.m. on Monday, July 28th, was the strongest

shock of the whole series. The last noticeable tremor seems to have taken place on July 31st.

The valley in which Mignano (province of Caserta) lies runs from north-west to south-east, up from the lowlands of Rocca d'Evandro into the hills of Mesozoic and Kainozoic limestone, which form its eastern and western walls. The valley is about 6¼ miles long, and through it is carried the railway-line from Rome to Naples. The valley-bottom is made up of volcanic materials overlying limestone, and Mignano itself is built on tuff. An ancient lava-flow, 1½ miles in length and half a mile broad extends from south-west to north-east down towards the railway from the base of Monte Friello. There are other lava-flows in the neighbourhood, of apparently less importance.

On the geological map, which accompanies the memoir, the author has traced the isoseismal curves, and these show that the epicentral area has a roughly triangular form, one of the angles being ½ mile north of Mignano, and the other two distant about 2 miles respectively, south-south-west and south-south-east of that place. Evidently the seismic focus lay at no great depth, comparatively speaking. The author calculates it roughly at 5,000 feet.

In the case of most earthquakes that take place in Italy the strongest shocks are felt at the beginning of the period of seismicity, but at Mignano, as we have seen, particularly violent shocks were observed at the middle and at the end of that period as well.

The various possible causes of the Mignano earthquake are discussed, but the author prefers not to pin himself down to a definite opinion until such time as the tectonic geology of the area is better known.

L. L. B.

EARTHQUAKE IN FINLAND, 1898.

Jordskalfvet den 5 *Nov.*, 1898. *By* K. A. Moberg. *Fennia*, 1901, *vol. xviii., No.* 6, *pages* 1-28, *with a map.*

The author collects in this paper all the observations recorded in respect of the earthquake which took place in northern Finland and part of Sweden, a few minutes before 1 o'clock on the morning of November 5th, 1898. The area over which it extended is shown by the isoseismic curves plotted out on the map that accompanies the paper.

Although at some localities two distinct shocks are said to have been felt, the records do not agree as to the interval between these shocks; and the greater number of reports concur in describing the earthquake as consisting only of one shock. It appears to have travelled from south-east to north-west, and caused no damage of any consequence. The sound, described as resembling the clattering of heavy cart-wheels on a hard frozen road, was much louder within the epicentral area than outside it. Moreover, the sound preceded the actual shock within the epicentral area, but outside that area sound and shock were simultaneous.

On the author's map are also plotted, for purposes of comparison, the isoseismic curves of the earthquakes which took place, they too around the Gulf of Bothnia, on June 15th and June 23rd, 1882. These isoseismic curves show that the epicentral area of the recent earthquake lies east-north-east of the similar areas of the preceding earthquakes. L. L. B.

THE SWEDISH EARTHQUAKE OF NOVEMBER, 1901.

Meddelanden om Jordstötar i Sverige. By E. SVEDMARK. *Geologiska Föreningens i Stockholm Förhandlingar*, 1902, *vol. xxiv., pages* 85-120, *and* 1 *map.*

Vermland is reckoned among those provinces of Sweden wherein earthquakes are of fairly frequent occurrence, and it formed the epicentral area of the earthquake which took place in the night of November 9th to November 10th, 1901. About one second before midnight, two immediately consecutive shocks were felt at Karlstad (the customary centre of the Vermland earthquakes), followed by a rumbling like thunder and by a series of after-shocks. The seismic waves travelled on the whole from north-west to south-east, and the latest and feeblest shock was observed about 2·30 a.m.

Having sent out circulars with the usual schedule of questions, the author received replies from 54 localities, and with the help of these he was enabled to plot out the isoseismic curves on the map which accompanies his paper. As above mentioned, Vermland forms the epicentral area, but the outer isoseismic curve extends from Christiania on the east to Upsala and Södertelge on the west, that is, almost as far as Stockholm.

The earthquake-sound, by some observers, is said to have culminated in something like a resounding thunderclap or the noise of a shot fired by dynamite. Allusion is also made to a glare or flash of light, which might possibly be due either to an electric discharge or to fluorescence. One does not gather that any damage to persons or property was suffered.

In Sweden, these seismic phenomena are in no wise associated with vulcanicity, rather may they be regarded as due to purely tectonic causes, such as sagging or settling along a line of fault, etc. L. L. B.

EARTH-TREMORS, ETC., AT ZI-KA-WEI, CHINA.

Phénomènes observés à Zi-Ka-Wei (Chine) lors de l'Éruption de la Martinique. By — DE MOIDREY. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences*, 1902, *vol. cxxxv., page* 322.

The observatory at the above locality in China is situated not more than 10 minutes of a degree distant from the meridian which corresponds in the Old World to the meridian of Martinique in the New World. Now, on the day and at the time of the eruption of the Montagne Pelée, the bifilar pendulum registered a sudden increase in the horizontal component (after a long period of magnetic calm), and for 8 hours thereafter the instrument was agitated by what must have been a mechanical cause. The mercury-column, too, of the great barometer quadrupled in thickness, acting as a sort of seismograph: this thickening was followed by a second sudden increase of the horizontal component, and that, after an interval of 3 hours or so, by a third. A quiet period of about 7 hours supervened, then a fresh disturbance took place, lasting far into the next day.

Thus in China, just as at Paris and at Lyons, a period of magnetic disturbance began at a time coincident with the Martinique eruption; and there were also earth-tremors, which appear to have taken about 4½ hours to travel from the West Indies to the far east of Asia. L. L. B.

THE PROPAGATION OF EARTHQUAKES.

Propagazione dei Terremoti. *By* GIULIO GRABLOVITZ. *Atti della Reale Accademia dei Lincei*, 1902, *series* 5, *Rendiconti, vol. xi., pages* 177-185.

From the complex of records obtained by modern methods of the seismographic registration three principal phases emerge:—

1. Rapid undulations which, coming, say, from Japan, reach Italy about ¼ hour after the commencement of the earthquake at the epicentrum, and are protracted for several minutes.

2. Slackened undulations, of greater amplitude than the foregoing, arriving 10 minutes later, or 25 minutes after the commencement at the epicentrum.

3. Slow oscillations of 15 seconds period, 30 minutes after the first phase, or 45 minutes after the commencement at the epicentrum. These oscillations generally attain their greatest amplitude 5 or 10 minutes after their first arrival, and they are preceded by extremely slow oscillations (of 60 seconds period), of inconsiderable amplitude and revealed alone by specially delicate instruments. This third phase occasionally lasts for a few hours, and the instruments available are hardly sensitive enough to determine the precise moment at which it ceases.

The author points out that the hypothesis of longitudinal and transverse oscillations, lately received with much favour, takes into account the first and the third phases, but leaves unsolved the problems attaching to the second phase. The intervals between the three phases and their duration increase concurrently with the distance from the epicentrum; and the author explains on what grounds he established his formerly suggested co-efficient of 186 miles (300 kilometres) for every minute's interval between the beginning of the first and that of the third phase. He now shows to what modifications this co-efficient is subject, in view of improved methods of seismographic registration, discussing for this purpose the results obtained by Messrs. Milne, Oldham and Belar. The varying velocity of the first phase causes the co-efficient to vary according to the distances, but the tabulated results show that the range of variation is, after all, not so very great, and the rough estimate of 300 was nearer the truth than might have been expected.

In the analysis of earthquakes over an area where the general public has been conscious of their occurrence, the distances dealt with rarely exceed 620 miles (1,000 kilometres). Moreover, at most points of observation, it is not the actual first oscillation that is recorded, but a more advanced phase, and even in recording this there is some delay. Then, although it is usual in dealing with remote earthquakes to regard the co-efficients of velocity as constant, we should bear in mind the modifications which they may undergo over short distances, in consequence of the predominance of strata more or less favourable to rapid seismic propagation. The third phase itself, of the ascertained velocity of 2 miles (3 kilometres) per second in the epicentral area, is more distinctly felt, and actually "overhauls" the others. The depth of the epicentrum, largely negligible over great distances, is a factor of considerable importance over short distances. The author concludes, therefore, that very precise observations, made with the very best instruments, are necessary, in order to deduce those laws which one may vainly attempt to build on incomplete and inexact narrations.

L. L. B.

FOLDING OF ROCKS IN RELATION TO EARTHQUAKES.

Sur l'Influence Sismique des Plissements armoricains dans le Nord-ouest de la France et dans le Sud de l'Angleterre. By F. DE MONTESSUS DE BALLORE. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences*, 1902, *vol. cxxxiv., pages* 786-788.

The author, a well-known seismologist, states that the object of this paper is to show in what measure the instability of the earth's crust is traceable to those post-Carboniferous, so-called Armorican, folds, which characterize the region now occupied by the south-west of Ireland, the northern shores of the Bristol Channel, Cornwall, and the French Palæozoic massif (Britanny, the Cotentin, and Vendée). Seismic epicentra are disseminated all over this area, but attention is directed to the manner in which those that are most frequently the *locus* of earthquakes are grouped together. Isolated and infrequently active epicentra may be generally traced, with a considerable show of reason, to some local geological "accident" or fault-line.

Epicentres may be traced along the Armorican folds in county Cork, and across into south-western Pembrokeshire (Haverfordwest, etc.), and thence right into the Mendips. The great fold disappears at Frome beneath the Mesozoic formations, but it is evidently continuous at some depth below the South Downs, reappearing in France, where its course is marked by seismic epicentra through the Boulonnais and into Belgium. In the same way a connection is traced between the Armorican folds and the seismic epicentra, from Dartmoor to the Scilly Isles and across to Britanny and in the Channel Islands. Metalliferous injections appear to have had no seismic influence in Cornwall, but the same assertion cannot be made in regard to the elvans. Nor do granitic intrusions, whether in Cornwall, or in south-western Ireland or in Vendée or Britanny, coincide with any important seismic epicentra.

The geological phenomena which resulted in the breaching of the formerly continuous land-line by the Irish Sea and the English Channel had no influence in determining the seismic instability of the area, any more than the late Tertiary elevations and subsidences. Similar observations hold good concerning many regions of the globe's surface, for such phenomena as these are too superficial, while the origin of the great folds may be very deep-lying.

"To sum up—the Armorican folds, despite their great antiquity, have retained a remnant of vitality, in the shape of fairly frequent, not very intense earth-tremors, with numerous epicentra." The older "Caledonian" folds, with which the Armorican folds are associated along the northern shore of the Bristol Channel, constitute, on the other hand, an element of stability.

L. L. B.

THE FOLD-THEORY OF EARTHQUAKES.

Les Tremblements de Terre de Plissement dans l'Erzgebirge. By F. DE MONTESSUS DE BALLORE. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences*, 1902, *vol. cxxxiv., pages* 96-98.

In the region, which is bounded by the Frankenwald on the west, the Eger on the south, and the Elbsandstein on the east, earthquakes without being, as a rule, of disastrous intensity, are of frequent occurrence. Geologists are generally agreed that the physiographical structure of the region is in great part the outcome of a triple folding, begun in Archæan times and continued during subsequent periods; this folding took place from south-east to

north-west, and thus arose three sensibly parallel ranges trending from south-west to north-east:—The Mittelgebirge being the southernmost, the Erzgebirge lying north of it, and the Liebschütz Hills north of that again. The Erzgebirge, the most elevated and longest fold of the three, slopes on the one hand down to the peneplain of Saxony, and on the other abuts as a great wall on the Eger Valley and the Bohemian volcanic fault. This fault-line is marked by many thermal springs, among which those of Franzensbad and Teplitz are the most renowned. The whole area has been injected with granitic and other laccolites, and complicated with basaltic flows. Metalliferous veins of various composition and age course in every direction through the rocks. In the troughs of the folds lie the more or less eroded sedimentary deposits.

The instability of the region is manifested by the number of epicentres, 150 or more, scattered all over it, but perhaps more closely clustereed together in the south-west of the Erzgebirge than elsewhere, and Graslitz and Brambach may be regarded as the districts of greatest seismicity. Now, the Graslitz-Brambach epicentres are evidently connected with certain huge quartz-reefs which fill up long fractures running at right-angles to the Erzgebirge range, and in some cases crossing even the Eger valley. Owing to this and other circumstances, the author infers that the folding movement begun in the dim recesses of Archæan time is still going on, and the recent earthquakes are its attenuated manifestations.

On the other hand, the innumerable fractures that characterize the Vogtland and Saxony have, on the whole, given rise to only a small number of epicentres. It is as if the quartz-infilling had cemented that area into a gigantic breccia, and thereby made it more stable than otherwise. Here then faulting has an exactly opposite effect, so far as seismicity is concerned, to folding a conclusion which is confirmed on examining the circumstances connected with the great Bohemian volcanic fault.

Saxon Switzerland, despite its rugged configuration, is a very stable area. A few unimportant epicentres along the right bank of the Elbe, are connected with the great dislocation of the Lausitzerwald granite.

The author points out, however, that it would be very rash to connect every seismic epicentre with some neighbouring geological dislocation or such like phenomenon. Still less is it advisable, as many seismologists have done, in the absence of visible geological disturbances, to regard earthquakes as the outward manifestation of unknown subterranean faults.

To sum up, in the Erzgebirge, out of three kinds of geological phenomena implying at least temporary instability (fracture-areas, volcanic "lines of least resistance," and folds) the last-named alone has remained a living force down to our own days, manifesting itself by means of earthquakes.

L. L. B.

THE RELATIONSHIP OF SOUND-PHENOMENA TO EARTHQUAKES.

Über die Beziehungen zwischen Erdbeben und Detonationen; and *Bericht über das Detonationsphänomen im Duppauer Gebirge am* 14. *August*, 1899. By J. KNETT. *Sitzungsberichte der Mathematisch-naturwissenschaftlichen Classe der kaiserlichen Akademie der Wissenschaften* [*Vienna*], 1900, *vol. cix., abtheilung I., pages* 700-734, *with* 3 *figures in the text, and pages* 735-767, *with* 6 *figures in the text and* 2 *plates.*

Pointing out in the first place the general consensus of experience that the sound which accompanies an earthquake is directly proportional in in-

tensity to the violence of the shock, the author draws attention to certain cases wherein the terrific loudness of the sound-phenomena has, however, been out of all proportion to the comparatively feeble vibration of the soil. To seek for the cause of these it seems needful to start from the premiss that certain "earthquake-sounds" or detonations are independent phenomena, the result of one or more causes originating in a particular focus, and the earth-tremors observed in connexion with them are merely accessory accompaniments originating in the same focus.

Feeble detonations are unaccompanied by any observable earth-tremors. Among such the author reckons the "Barrisal guns" of Java, the Gangetic plain, and the Congo, the "Marina" of the Umbrian coast, and the "Mistpœffers" or "Zeepœffers" of the Flemish coast. These phenomena, feeble though they be, are remarkable for their continual recurrence at the same localities, and it may be remembered that Prof. George Darwin has assigned them to microseismic movements of the earth's crust.

Of another order are the "detonation-swarms," consisting of a more or less rapid succession of thunderous sounds, in a region where they have not occurred before and do not recur so far as we know. Such "swarms" may go on for weeks, months, or even years at a time. Such were those of Guanaxuato (Mexico) lasting from January 9th to February 14th, 1784: of Villaga, Italy, from November 4th to December 26th, 1851; of Meleda, Dalmatia, lasting from 1822 to 1825. After a short description of these, the author proceeds to discuss minutely the relation between tremor and detonation, and seeks to prove that in a given medium both travel with an equal velocity—in a word, that the seismic and acoustic waves transmitted by ponderable matter have much the same mutual relationship as the electromagnetic and optical waves transmitted by imponderable matter. This equality of velocities in the purely seismic phenomena of the lithosphere applies only to the rapid [transverse] vibration-waves. What the author terms "not purely seismic, or mixed" phenomena of the lithosphere, such as tremors connected with certain volcanic eruptions, give rise to acoustic waves which, however, are propagated with the slow [longitudinal] earth-waves. He enunciates his "detonation-theory" as follows:—Earth-sounds are for the most part mixed phenomena of predominantly acoustic origin. These are propagated from their focus through the earth's crust by means of waves which correspond to the earthquake-waves proper (slow waves), and possess the same velocity as the last-named. The "report" of such detonations bears no analogy to the noises heard before the principal shock in most earthquakes. The detonations are of various intensities, and are, as a rule, accompanied by vibrations of the surface of the environing medium, the intensity of such vibrations being generally concordant with that of the "report."

Detonations are classified by the author, according to their degree of intensity, in five categories, and he emphasizes by description and diagram the distinction between these phenomena and earth-tremors. He then endeavours to trace out the possible causes of the phenomena, and refers in this connexion to sudden outbursts of gas below ground and to the sudden caving-in of subterranean caverns, etc.

In his second memoir, he describes the detonation-phenomena observed around Duppau in Bohemia on August 14th, 1899, between 6 and 6.15 p.m. These consisted of a couple of subterranean "thunderclaps" of medium intensity (3 in the author's scale), accompanied by a feeble earth-tremor (2 to

3 in the accepted scale). The sky was cloudless, and the first "clap" was especially startling. The localities where the sounds were observed fall within a circle, the diameter of which does not exceed 8½ miles. After a very detailed discussion of the facts, including considerations on the form of undulations and the possibility of "total reflection" within the earth's crust, the author points out that the volcanic massif of Duppau, which is cut in two by the great Bohemian fault, arose along two main dislocations with which are connected a number of smaller faults. The district is no stranger to the seismic phenomena, but the author appears inclined to attribute the "detonations" to an outburst of gas taking place among the rocks at some depth below the surface. L. L. B.

THE CAUSES OF EARTH-TREMORS.

Bradisismi e Terremoti della Regione Benacense. By G. B. CACCIAMALI. *Bollettino della Società Geologica Italiana*, 1902, *vol. xxi.*, *pages* 181-196.

A study of recent earthquake-phenomena in Northern Italy, as well as of the Tertiary and prehistoric seismology of the same region, has led the author to the following conclusions, among others:—

1.—The slow oscillations of the soil (or bradyseisms) affect considerable areas of the earth's surface; whereas the rapid oscillations (or earthquakes) are comparatively localized, although the undulations may be propagated over regions of far greater extent (eccentric earthquakes) than those subject to bradyseismic influence.

2. The crumplings and contortions of the strata, the lines of faulting, dislocation, and fracture, amid rocks of the same age, prove that bradyseismic phenomena have taken place in all geological periods. The limiting-lines of the bradyseisms may be parallel or sub-parallel, continuous or interrupted, straight or sinuous.

3. The principal seismic areas are grouped in relation to these lines, and therefore most earthquakes are connected with the tectonic irregularities of the area in which they occur. So then, most earthquakes are intimately connected (by derivation) with bradyseismic phenomena.

4. The settling-down of the rock-masses which form the earth's crust, is the cause both of bradyseisms and earthquakes. But the latter, just as are volcanoes, are subordinate to the former, which constitute the chief factor in orogenic development. It is sheer obstinacy of scientific tradition to attribute earthquakes to any other cause that can be raked up except this slow sagging (such as tension, liberation, or subterranean explosion of gases movements of molten magmas, etc.). So too, by inveterate habit, in referring to orogenic development or mountain-building we speak of uplifts of the soil, whereas the secular sagging resolves itself mostly into subsidences.

5. The mode of juxtaposition and junction of rock-masses consequent on the final or quasi-final settling-down of a given area, is a factor which tells against ulterior movements among these masses. So the bradyseismic areas tend more and more to become localized, until they become identical with tachyseismic (earthquake) areas, and these tend finally to disappear.

The author states that he does not pretend to have said the last word on the subject, but rather to have shown the way whereby we may finally attain to a rational and correct explanation of telluric phenomena. L. L. B.

THE DIURNAL OSCILLATIONS OF THE SOIL.

Die tägliche periodische Schwankung des Erdbodens nach den Aufzeichnungen eines dreifachen Horizontalpendels zu Triest. By EDUARD MAZELLE. *Sitzungsberichte der Mathematisch-naturwissenschaftlichen Classe der kaiserlichen Akademie der Wissenschaften* [*Vienna*], 1900, *vol. cix., abtheilung I., pages* 527-651 *and* 5 *plates.*

This very exhaustive memoir, amply illustrated by plans, diagrams of curves, tables of results, etc., gives an account of the observations systematically conducted at the Imperial Observatory in Trieste, by means of the Rebeur-Ehlert horizontal pendulum, as to the periodic oscillations of the soil. The hill on which the observatory is built consists of Flysch (older Tertiary) marls and sandstones, which abut on the north-east upon the limestone-plateau of the Triester Karst. The pendulum is borne by a pillar of limestone erected on a sandstone-and-cement base (independent of the floor of the Observatory), which at a depth of 4½ feet rests on the live rock (sandstone). The room in which the instrument is set up is practically underground, and during a period of sixteen months the average variation of temperature from one day to the next was only 0·23° Fahr., and the diurnal variation averaged 0·55° Fahr. This is about $\frac{1}{15}$th of the amplitude of temperature-variations observed at the same time in the outside atmosphere.

The general conclusions at which the author has arrived may be summarized as follows:—

The observed oscillation of the pendulum-pillar during the course of a day is expressed by an ellipse, the great axis of which is directed east 20° north and west 20° south. The most considerable deviation to the east-north-east occurs after 4 a.m., and that towards the west-south-west after 1 p.m. The influence of the meteorological elements on the periodic oscillation is betrayed by the observation that the oscillation is most regular in August (the month which at Trieste shows the greatest percentage of sunshine, the fewest clouds, and the least rainfall), and most complicated in January (the month of least sunshine and greatest rainfall).

The memoir contains many other interesting results and considerations which cannot be dealt with in an abstract. It may be pointed out, however, that the observations bore on semi-diurnal as well as on diurnal oscillations. L. L. B.

THE SEISMOLOGICAL OBSERVATORY AT BUDAPEST, HUNGARY.

Mitteilung über die erste Einrichtung der Erdbebenwarte in Budapest. By DR. FRANZ SCHAFARZIK. *Földtani Közlöny*, 1902, *vol. xxxii., pages* 268-269.

Regular work was begun at this establishment on March 1st, 1901, and records of observations are published every two months. The *locus in quo* consists of a basement, 135 feet away from the street and 16½ feet below road-level, in the new building of the Royal Hungarian Geological Institute. This is situated in a quiet suburban district.

As seismographs, two horizontal Grablovitz-Omori pendulums, made by Mr. Bosch of Strasburg, are used. One is placed in a north-and-south direction, and the other at right angles to it. The whole installation is mounted on isolated stone-pillars, sunk in the earth about as far down as the water-level of the sandy drift-deposits. The normal temperature of the basement is 58° Fahr.

With this apparatus, only shocks of some importance can be registered.

Earth-tremors, such as those caused by the railway-trains which rattle past half a mile or so away, or by batteries of artillery going along the road, are not recorded by it. The records are traced automatically on blackened paper.

Disturbances registered on April 19th, 1902, were doubtless associated with the Guatemala earthquakes; and those recorded on July 5th and August 22nd in the same year were similarly connected with seismic phenomena of which the centre lay at Salonika in the first instance, and Kashgar in the second. L. L. B.

UNDERGROUND SEISMOLOGICAL OBSERVATORY AT PRZIBRAM, BOHEMIA.

Die unterirdische Erdbebenwarte in Przibram. ANON. *Centralblatt für Mineralogie, Geologie und Paläontologie*, 1903, *No.* 7, *page* 238.

The Vienna Academy of Sciences has defrayed the cost of setting up Wiechert pendulum-seismographs above- and below-ground at Przibram. Above-ground, the instruments are lodged in a small stone-building, in which besides the seismograph are various electric batteries, a clock, and a telegraph-apparatus, to which the exact time will be signalled from the Vienna astronomical observatory. Below-ground, the seismograph is set up in a walled chamber in the Przibram mine, at the depth of 3,657 feet: an electric cable 8,528 feet long joins up the underground seismograph with that above-ground. Each of these two instruments weighs 2,645 pounds.

Among the unfavourable conditions attending the installation may be mentioned the continuous vibration due to the ore-picking machinery. There are also unavoidable variations of temperature which cause the pointers to oscillate slowly, but continually. Ingenious corrections have been applied to eliminate these disturbing factors, and apparently with success. A distant earthquake of some importance was recorded recently by both instruments, and the records from above- and below-ground agreed in practically every particular. L. L. B.

SEISMOLOGICAL OBSERVATORIES IN THE GERMAN EMPIRE.

Ueber Vertheilung, Einrichtung, und Verbindung der Erdbebenstationen im Deutschen Reich. By G. GERLAND. *Petermanns Mittheilungen*, 1902, *vol. xlviii., pages* 151-160, *with a map in the text.*

The movement for establishing on the Continent of Europe a network of observatories where earthquake-phenomena will be duly recorded, and the results of scientific work properly co-ordinated, is proceeding apace. Much is due to the intelligent interest which the various governments concerned manifest in the matter, as well as to the perseverance and enthusiasm of such experts as the present author. His paper embodies the plans which he is drawing up for the distribution of seismological observatories within German territory. The central station is at Strasburg in Alsace, and he proposes eleven other main stations at Aix-la-Chapelle, Karlsruhe, Darmstadt, Munich, Göttingen, Hamburg, Leipzig, Jena, Breslau, Königsberg, and Potsdam. These localities are not selected haphazard, but after careful consideration of the tectonic structure of the country, that is, the main lines of faulting and folding of the rocks. In addition, twenty-five stations of secondary importance are suggested, and the author asserts that the

number proposed will be sufficient, but not more than sufficient, to carry on properly a seismological service. The most important duty that will fall to the secondary stations is the collection of replies to printed formularies regarding time, duration, effects, etc., of earth-tremors. These replies, when collected, will be despatched to the nearest main station, to which also monthly reports will be sent concerning the observations made with the simple apparatus in use at the secondary stations (automatically-recording pendulum, etc.).

The chief task incumbent on the main stations will be the recording of microseismic movements and of distant earthquakes. The apparatus there will consequently be of a more complicated and costly description than that provided for the secondary stations. For instance, the Rebeur horizontal pendulum and the Wiechert astatic pendulum will be set up in them. Monthly and yearly reports will be issued from each main station regarding its own district; and here it may be observed that the delimitation of seismological districts according to political boundaries will but seldom fit in with a delimitation based on scientific grounds.

The Imperial Central Station at Strasburg will furnish a conspectus of the microseismic phenomena recorded throughout Germany, and the area of propagation of every important earthquake will be mapped as accurately as possible, the whole of the information being published yearly somewhere about the month of April. The apparatus from the subordinate stations will be continually tested at the central station, new instruments experimented with, and so forth. The entire organization is under the superintendence of a committee, on which sit two representatives of the Government.

Finally, it is proposed to establish underground observatories in the mines at Freiberg, Zabrze, and Klausthal, to supplement the records obtained from the observatories above-ground.

The author lays due stress on the enormous practical importance of the organized study of seismological phenomena; for the miner, the architect, the builder, and the manufacturer, may all find themselves called upon at any moment to deal with problems dependent on such phenomena.

L. L. B.

A SEISMOGRAPH FOR VIOLENT EARTHQUAKES.

Sopra un Sismografo per Forti Terremoti. By G. AGAMENNONE. *Atti della Reale Accademia dei Lincei, series* 5, *Rendiconti*, 1902, *vol. xi., pages* 116-122, *with a diagram in the text.*

This new instrument, called by the author, the macroseismometrograph (in contradistinction to the microseismometrograph) has been devised to record earthquakes which are of such intensity as to render useless the habitual, more sensitive, recording-instruments. Its necessity was proved by the Latian earthquakes in recent years, when all the instruments in the Rocca di Papa Observatory and at the Seismic Experimental Station in Rome were thrown out of gear. The new macroseismometrograph was set up in the Royal Geodynamical Observatory of Rocca di Papa, in September, 1901.

Premising that for the proper study of earthquakes the vibrations of the soil should be resolved into three components at right angles one to the other (that is, two horizontal and one vertical), the author describes the construction of the two small horizontal pendulums which he uses for

registering the first two components. Their method of suspension is very similar to that adopted in Ewing's bracket-seismometer, and is so contrived that the most powerful shocks directed against the base of the instrument will not sensibly affect the due working thereof. The period of a simple oscillation is 4 seconds, exactly as if we were dealing with a vertical pendulum, 52 feet long. For the registration of the vertical component, the author uses a heavier mass of lead (4·4 pounds) than the cylinders constituting the bobs of the horizontal pendulums (3·3 pounds), the suspension from four steel-supports being also on the Ewing system. The entire apparatus has been arranged with a view to great economy of space, and the records are automatically traced by the three styles connected with the respective pendulums, on a smoked and lacquered paper-roll, about 10 inches broad and 11¼ feet long. The author describes the simple mechanism whereby rapid and also accurate rotation of the roll is secured. Moreover, on the same roll, a fourth style, electrically set in motion by a chronometer, marks off the seconds and minutes of time.

No sufficiently violent earthquake, he remarks, has occurred since September, 1901, at Rocca di Papa, to enable him to state that the macro-seismometrograph has fulfilled all his expectations. It is true that the new instrument was set in motion on October 15th of that year, when a shock of considerable intensity occurred in the Abruzzi, and on December 16th, when an earthquake of moderate intensity took place in Umbria: but, as might have been expected, the styles on each occasion traced out perfectly straight "curves" (if the anomalous expression be permissible). This sufficed to show, however, that the whole mechanism works well. Before setting up the instrument at Rocca di Papa, the author had experimented on it with as good an imitation as he could devise of seismic vibrations, and was sanguine from the results thus obtained that it will prove to be of great practical value. He figures the artificial seismogram obtained in the course of these preliminary experiments, and takes occasion to point out the necessity for great speed of revolution of the recording-roll.

L. L. B.

COAL-OUTCROPS.

Coal-outcrops. *By* CHARLES CATLETT. *Transactions of the American Institute of Mining Engineers*, 1900, *vol. xxx., pages* 559 *to* 566 *and* 1105 *to* 1109.

The writer draws attention to the extent to which a bed is affected by its outcrop at the surface; and having examined a number of openings immediately at the surface, and also a short distance under cover, he gives a number of actual sections bearing on the subject.

Whatever may have been the original variations, it may be assumed that coal-basins presented in comparatively modern times approximately parallel beds interstratified with fire-clay, slate, sandstone, etc. It is obvious that, along the lines of actual outcrop, the beds exist under different conditions from those ruling at some distance under cover in their exposure to atmospheric agencies, pressure and erosion. The effect of the first is to decompose and soften many of the strata; of the second, when exerted unequally, to cause the movement of such material as was at all plastic towards the point of least pressure; and of the third, to remove the strata wholly or in part. The pressure is not as great at or near the outcrop as it is some distance under cover, and the tendency would be

to increase the thickness at the former point. This is usually not conspicuous, since the material thus forced to the surface is peculiarly subject to erosion and removal, so that the effect on the level of the various strata is small, and is often offset by local conditions. Yet it exists; and in places where the beds of coal are underlain by thick beds of plastic fire-clay, they commonly show a dip from the outcrop, owing to the thickening of the fire-clay bed at that point. Of the sections given, the thickness of coal shows under cover an average increase of 6 per cent. in 6 sections, and a decrease of nearly 5 per cent. in 7; while the thickness of partings increases 27 per cent. in 5 sections, and decreases 30 per cent. in 6.

An examination of the sections will disclose a marked similarity between the seam at the surface and when opened a reasonable distance under a solid top. The changes due solely to the nearness of the surface can be recognized and allowed for, so that it is possible to form from the outcrop a very nearly accurate idea of what may be expected 50 or 60 or 75 feet under the top. A very soft, sooty material, called "mother-coal," may pass, in that distance, into a coherent but friable material, usually exceedingly pure. Hard streaks in the coal are emphasized at the surface; and a material which is coal, but is obviously high in ash, may be found, owing to the increase of oily and volatile material, to become of fair quality and be classed as pure coal. A slaty material, which is very black and friable, will, as a rule, pass into inferior coal, and, when in small quantities, would probably be described as bony coal at 50 feet from the outcrop. Hard, undecomposed grey slate, on a well-defined bed, may be expected to continue as such without alteration. A plastic slate or fire-clay, existing as part of the coal-bed, may usually be expected to thin very considerably within a short distance, as its section is generally increased by the reduction of pressure at the outcrop. A. W. G.

THE THEORY OF EROSION IN RELATION TO METALLIFEROUS DEPOSITS.

Sur la Notion de Profondeur appliquée aux Gisements Métallifères Africains. By L. De Launay. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences*, 1902, *vol. cxxxiv., pages* 1531-1533.

The author had previously expressed the opinion that the characteristic type of metalliferous deposits in a given region might depend on the depth reached by erosive agencies in that region; or, in other words, on the depth at which that portion of the deposits now being mined lay, when those deposits were formed. The depth to which erosion, reducing an area more or less to the form of a plateau, has gone, bears some relation to the epoch at which the latest folding of the area took place.

In order to test this hypothesis, it is necessary to enter on the comparative study of countries which have undergone folding at different epochs, with the view of showing that their metalliferous deposits fulfil the postulated conditions. The author commenced with the African continent, the southern portion of which was last folded in Carboniferous times, while the north-eastern portion underwent folding as late as Tertiary times. These two regions, in regard to their metalliferous deposits, show precisely the antithesis required by the author's theory.

The metalliferous deposits of Algeria and Tunisia are manifestly connected with the littoral volcanic belt, and consist of complex sulphide veins

containing variable proportions of iron, copper, lead, zinc, antimony, and mercury. These veins are very much scattered, crushed, and dislocated amid a chain of (geologically) very recent folds. Copper and iron are predominant near the coastal eruptive belt, while zinc and lead predominate farther away from it. Erosion has not gone on long enough to plane down the irregularities of the surface, and so the general water-level of the country lies often at a great depth; there is consequently very active circulation of underground waters, and oxidic metamorphism of the various metallic sulphides is widespread and deep-reaching.

All other known ore-deposits on the African continent differ entirely from those just described as characteristic of its north-eastern portion. The "filonian" or vein-type, properly so called, is conspicuous by its absence, and the metalliferous deposits are in the form of lenticles, pockets, "bedded-veins," or impregnations. Besides hæmatite, magnetite, iron-pyrites, we have here copper and nickel-ores, and the characteristic occurrence of gold. Erosion having cut down to the old crystalline rocks, the ores associated with these become accessible, such as tin and bismuth in the granites, chrome-iron-ore and nickel in the peridotites and norites. Mercury is absent, zinc and lead-ores are comparatively scarce. The superficial oxidation of the ores extends very little downward. In a word, nothing in the Sudan, the Congo Basin, Katanga, the German protectorates, Rhodesia, or the Transvaal, but what shows diametrically opposite characteristics to the deposits of the newer portion of the continent (Algeria, Tunisia, etc.).

L. L. B.

THE ORIGIN OF KAOLIN-DEPOSITS.

Beiträge zur Kenntniss einiger Kaolinlagerstätten By H. RÖSLER. *Neues Jahrbuch für Mineralogie, Geologie und Paläontologie*, 1902, *Beilage-Band XV., pages* 231-393, *and* 3 *text-figures.*

This painstaking memoir gives, in the first place, a most elaborate bibliography of the subject, comprising no less than 303 entries. Then follows an introductory chapter dealing mainly with the chemical composition and physical properties of kaolin, and the author lays stress on the fact that wherever the mineral occurs it is undoubtedly a decomposition-product. He tabulates synoptically the changes in chemical constituents whereby the felspars (orthoclase, albite and anorthite respectively) are transformed into kaolinite. Some writers believe that the kaolin of Passau in Bavaria is derived from the decomposition of scapolite, but the author shows that scapolite cannot by any possibility give rise to kaolin.

The minerals more or less frequently associated with kaolin are dealt with in detail, and the author then proceeds to describe a great number of deposits from Bornholm in the north to Limousin in the south, and from Bohemia in the east to Cornwall in the west. Those of Cornwall and the Bourbonnais are, it is well known, intimately associated with the occurrence of tin-ore; while in Colorado kaolin-deposits are associated with galena, pyrites, and silver-ores, and in New Mexico with turquoise-bearing veins. In the neighbourhood of Passau in Bavaria, of Schwarzbach and Krumau in Bohemia, and also in Ceylon, kaolin is associated with graphite-deposits. There are, of course, numerous examples of kaolinized granites unassociated with any other mineral-occurrence of industrial interest; as, for instance the kaolin-deposits around Karlsbad (described at great length), those of

Oberlohma near Franzensbad, those of Tirschenreuth and Wiesau in the Upper Palatinate, etc.

The author deals separately with kaolinized aplitic veins and apophyses in crystalline schists. He sees in these undoubted evidence that kaolinization took place through post-volcanic changes within the aplite-intrusions themselves. The most extensive occurrences of this type are the deposits of Limousin in Central France. On the other hand, the most important German deposits of kaolin occur among the quartz-porphyries and associated rocks of Saxony, along an east-and-west line defined by the towns of Meissen, Mügeln, and Halle. These occurrences are described in some detail.

Some attention is then given to the secondary kaolin-deposits (or placers as we might call them) containing kaolin drifted by water-transport from its original *locus*, and forming kaolin-sandstones, kaolin-clays, and refractory clays.

The author points out that weathering is not the cause of kaolinization: the two processes are fundamentally distinct, and their terminal products cannot be confounded one with the other. Kaolinization is started in quite a different way from weathering, one proof among others being that semi-kaolinized rocks, when exposed to weathering agencies, do not become further kaolinized, but simply crumble away to fragments.

He considers that the agents of kaolinization came from below, in the form of vapours and hot solutions, chief among them being fluoric, boric, and sulphuric acids. These exhalations and thermal waters probably acted with far greater intensity than any of those now active, and no doubt date back to an epoch of great vulcanicity,—perhaps to the times immediately following on the eruption of the granites and quartz-porphyries.

L. L. B.

THEORY OF FORMATION OF PETROLEUM.

Synthèse de divers Pétroles: Contribution à la Théorie de Formation des Pétroles naturels. *By* P. SABATIER *and* J. B. SENDERENS. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences*, 1902, *vol. cxxxiv.*, *pages* 1185-1188.

By acting on acetylene with hydrogen gas in presence of a column of finely-divided nickel maintained at a temperature of 200° Cent., the authors obtained in a cooled tube, a liquid possessing much the same chemical composition, physical characters, and specific gravity as American petroleum. By directing upon a similar column of nickel at a similar temperature a rapid current of acetylene, the authors ultimately obtained a greenish liquid possessing the characteristics of Caucasian petroleum. They describe the distillates obtained by fractionation, and they point out that intermediary oils (between the American and the Caucasian) are produced, if the acetylene before reaching incandescence is mixed with a given proportion of hydrogen. If hydrogenation, subject to incandescence, is carried on at a temperature higher than 300° Cent. oils possessing the characteristics of Galician petroleum are obtained.

From these synthetic experiments the authors deduce their theory of the formation of petroleum in nature. They suppose that in the depths of the earth are variously distributed in the free state alkaline and earthy-alkaline metals, as well as the carbides of the same. Water coming into contact with the metals sets free hydrogen, and when it comes into contact

with the carbides acetylene is given off. These two gases, in varying proportions meet in the finely-divided state metals which are in nature of very widespread occurrence, such as nickel, cobalt, and iron. Thus the conditions of the authors' synthetic experiments are fulfilled, the reactions which they have reproduced take place, and the different varieties of petroleum are formed. Messrs. Berthelot and Mendelejev had already hinted at this theory, which is by no means intended to be of universal application. Thus Dr. Moissan's idea that some petroleum is formed direct by the action of water on metallic carbides still holds good; and, so too, much petroleum is of animal or vegetable origin.

But none of the theories hitherto proposed had fully accounted for the diversity of natural oils. The authors claim that this is now satisfactorily accomplished, their syntheses being especially helpful in throwing light on the genesis of Caucasian petroleum. L. L. B.

THE ORIGIN OF PETROLEUM.

The Origin of Petroleum. By JULIUS OHLY, Ph.D. *Mines and Minerals*, 1902, *vol. xxii., pages* 532-533.

The theory that petroleum has been derived from the decomposition of vegetable matter has been widely, if not generally accepted, but the author rejects it for very cogent reasons. Petroleum has been found in strata where the vegetable matter could not have been forthcoming in sufficient quantity, whilst by referring it to the Carboniferous age, we get the necessary organic débris, but fail to find that the necessary heat was to be had. The author falls back on the theory that the oil has been produced from carbonaceous metallic compounds, and thinks that this view will be generally adopted in the future.

Explaining this theory, he remarks that elements of lower atomic weights, such as carbon, calcium, iron, etc., predominate in nature. Carbon and iron especially are amongst the most widely diffused elements, they are most difficultly fusible, and hence most easily condensed. They must have been the first bodies to liquefy during the incandescent stage of the earth's development. While the terrestrial temperature was yet a temperature of dissociation for most bodies, the liquid iron and carbon, by reason of their affinity and the high degree of heat, presumably combined with each other at that remote geological period. As the earth cooled, these large quantities of carbonized iron in the liquid state were brought into contact with steam, and gaseous hydrocarbons were formed. These rose by crevices and fissures to the overlying strata, were condensed accordingly, and meeting the water percolating the earth, were carried by their inferior gravities to the upper strata, and, in some cases, to the surface, where by oxidation they gave rise to the formation of bituminous shale, oil-sand, asphalt, ozokerite, and similar bodies, while the uncondensable part escaped as gas. It appears plausible to assume that the same process is still progressing in the earth's interior, or otherwise the inexhaustible productivity of the oil-basins becomes inexplicable.

The crude petroleum thus produced consists of a mixture of hydrocarbons, the paraffin series prevailing as a rule, the carbon and hydrogen percentages approaching the figures 85 and 15. Of these hydrocarbons, the members of the paraffin series, from methane down to pentadecane, have been

isolated. Methane is usually met with on boring for oil, and is exhaled from the gas-wells of Pittsburg, while ethane, the second member of the series of the formula C_2H_6, constitutes the gas of the Delameter gas-well in that city. The gas escaping at Baku is of the same nature, being methane, while pentane (C_5H_{12}), the fifth member of the series, prevails in the distillation product of petroleum, known as gasoline.

When steam is conducted over heated cast-iron filings, containing carbon, a number of hydrocarbons are produced besides oxides of iron. The chemical equation for this reaction is $3\,Fe_m C_n + 4_m H_2O = mFe_3O_4 + C_{3n}H_{8m}$. In this manner then the hydrocarbon C_3H_8, or propane, the third member of the series mentioned, is produced among a number of other higher hydrocarbons. This compound is a colourless gas known to occur in crude petroleum, an observation which agrees with the researches made into the nature and composition of Pennsylvanian oils. Other carbides, as calcium, for instance, give rise to the formation of the first member of the acetylene series, C_2H_2, giving further support to the theory of mineral origin. The equation for the formation of acetylene gas is:—$CaC_2 + H_2O = C_2H_2 + CaO$; and $CaO + H_2O = Ca(OH)_2$. No objection can be made as to the probability of this decomposition-process having occurred, and most likely pursued its course in the interior folds of the earth's structure. Moreover, acetylene polymerizes at a low red heat to benzine (C_6H_6) if its vapours be conducted through red-hot tubes, so that its formation under the pressure and heat existing in ancient strata becomes quite probable. Besides, the presence of hexahydrides of benzene, toluene, xylene, and pseudo-cumene in most natural hydrocarbons has been proved. If to these observations be added the fact that naphthaline is produced, together with benzine and styrene, by passing vapours of methane through heated tubes, the complexity of the natural product issuing from the oil-wells becomes better understood.

Admitting then that the conditions prevailing in those ancient geological zones were and are favourable for the production of petroleum, and that the temperature required for its generation, and the pressure which materially facilitates its formation cannot be met with in other strata of the earth, the general acceptance of the mineral theory appears probable. Any phenomenon occurring when prospecting for petroleum, like the escape of large quantities of gas exhibiting the character of methane, can be readily explained and understood by the above principles. It becomes evident, that in the great geological changes, which have given rise to the creation and separation of petroleum, the whole series of homologous hydrocarbons has been produced, from methane up to the highest paraffins. As to naphthenes, which closely resemble the paraffins, their occurrence in American petroleum has not as yet been observed, though their presence in the Russian oils has been proved.

X. Y. Z.

PETROLEUM IN THE LAST CENTURY.

Ueber Erdöl im 19ten Jahrhundert. *By* Josef Muck. *Berg- und Hüttenmännisches Jahrbuch der k. k. Bergakademien zu Leoben und Přibram*, 1902, *vol. l.*, *pages* 117-148.

In this not too lengthy paper, the author satisfactorily carries out his intention of giving within a small compass a general view of the present condition of the petroleum-industry all over the world. A brief historical

introduction is followed by a tabular synopsis of the districts and the geological formations in which petroleum is known to occur; and it may well be said that the countries where the oil does not occur are few. Diagrams and tables are given showing the increase in the world's output from 1859 to 1900, the United States and Russia so far overtopping all other producers that any attempt at comparison with these appears ludicrous. It may be noted, however, that the province of Eshigo, in Japan, supplies 80 per cent. of the amount of petroleum consumed in that empire, and that Sumatra and the neighbouring islands are coming rapidly to the fore as producers.

The origin of petroleum is discussed at some length, and the author inclines to the belief that it is mostly the result of the slow distillation of animal-remains, especially fishes—swept perhaps by currents into such supersaline gulfs as that of Karabugas, killed there *en masse*, and buried beneath sandy and clayey deposits. He points out how precisely those geological formations where petroleum is most abundant supply evidence in support of this hypothesis.

Petroleum-refuse, *massut* as it is called at Baku, forms now the principal fuel in use on the southern Russian railways, on the Caspian and Black Sea steamers, etc., and seems destined ultimately to monopolize for a time the place hitherto held by coal in the navies of the world. Its use would nearly double the radius of action of a man-of-war, not to speak of other advantages which are dwelt on by the author.

The statistics of 1900 from Baku and North America concur in showing that, as the number of oil-wells increases, the output per well decreases proportionally. So too the depths at which the oil must be sought increase. The word "inexhaustible," so freely and frequently used, is therefore hardly applicable, even to these great oil-fields. L. L. B.

THE GEOLOGY OF GRAPHITE.

La Géologie du Graphite. *By* L. DE LAUNAY. *Annales des Mines*, 1903, *series* 10, *vol. iii., pages* 50-86, *with* 7 *figures in the text.*

The author adopts the eclectic view that the various forms of mineral carbon which occur in nature may in some cases be of inorganic, in others of organic, origin; and further, that in yet other cases their origin is complex. The work carried out by various distinguished chemists during the last 40 years shows that there are in reality several forms of graphite, differing in chemical properties and in the mode and temperature of formation.

A brief description, compiled from various well-known sources, is given of the graphite-deposits of Siberia (now abandoned), Ceylon, Bavaria, Bohemia, Styria and the Alps; and the industrial side of the question is relegated to an elaborate footnote, wherein the graphite-production of Austria during 1901 is stated at 34,000 tons, of Italy 10,300 tons, of Bavaria 9,000 tons, of the United States 2,600 tons, and Canada 1,700 tons. That of Ceylon is not stated.

The Siberian graphite, which occurs in nests and irregular masses in nepheline-syenite, is regarded by the author as of deep-seated and inorganic origin. He appears to agree generally with Mr. E. Weinschenk that the Ceylon graphite associated with granulites, garnetiferous gneisses, pyroxenites,

etc., is also of deep-seated and inorganic origin; but he regards Mr. E. Weinschenk's assimilation of the origin of the Bavarian and Bohemian graphite to that of Ceylon as problematical, to say the least. In fact, he points out how it is quite possible that the entire series of rocks, in which the graphite occurs in the two last-named countries, is a metamorphosed succession of sedimentaries.

The author feels no doubt whatever that most of the Alpine graphite-deposits are of organic origin, and he notes that in Liguria the graphite is associated with anthracite.

We have, then, in some cases to deal with graphites formed by the crystallization of carbon in molten magmas or sublimed from fumarolles amid acidic rocks and quartzes; and in other cases with graphites derived from the baking (by regional metamorphism or otherwise) of deposits of organic carbon. L. L. B.

THE AURIFEROUS DEPOSITS OF ROUDNY, BOHEMIA.

Das Goldvorkommen von Roudny in Böhmen. *By* P. Krusch. *Zeitschrift der Deutschen geologischen Gesellschaft*, 1902, *vol. liv., Protokolle, pages* 58-62, *with a plan in the text.*

The author claims that his is the first description, from the scientific point of view, of these deposits, which lie about 37 miles south-south-west of Prague, and some 9½ miles east of Wotitz (a station on the Franz Josef Railway). They were worked from the fourteenth century onward until 1804, and have been recently opened up again after a lapse of well nigh a century. The old waste-heaps are about 100 feet high.

The district is reckoned to belong to the primeval-gneiss region of Bohemia; but the author found that the country-rock is really a granite, which in places assumes a gneissose structure. Or perhaps it would be better to say that we are dealing with three main varieties of rock:—(1) A normal grey biotite-granite, (2) a crushed, plicated gneissose granite, and (3) amphibolite or hornblende-rock, all three being traversed by dykes of haplite. A system of east-and-west fissures strikes through these rocks, usually dipping steeply northward; the fissures are only a very few inches wide, and are infilled with quartz and auriferous pyrites. There is usually an impregnation-zone extending into the country-rock, which is more or less altered thereby. As a rule the gold is combined with the pyrites, but it occurs also native (in an extremely fine state of division) in the quartz, or in the form of flakes or crystals on the walls of cracks within the quartz and pyrites. The proportion of gold varies from *nil* to 1 part per 10,000 of the vein-stuff. The thinnest fissures are richest, and the more finely-crystalline pyrites is richer in gold than the coarsely crystalline.

There appears to be little doubt that the deposits originated in the upward percolation of thermal waters carrying pyritous and auriferous particles in solution. These decomposed the granite in the neighbourhood of the fissures, and the reactions thus set up caused a precipitation of gold-bearing pyrites and gold-bearing quartz. The hornblende-rock resisted the decomposing action of the thermal waters more obstinately than the granite, with the result that it now contains practically no gold. It is evident that these processes took place before the intrusion of the haplite-dykes, and before the system of transverse, north-and-south, barren fissures began to form. L. L. B.

THE CORRELATION OF THE BOHEMIAN COAL-MEASURES.

Geologische Beobachtungen im Kladno-Schlaner Steinkohlenbecken. *By* Dr. K. ANTON WEITHOFER. *Verhandlungen der kaiserlich-königlichen geologischen Reichsanstalt*, 1901, *pages* 336-338.

The author has ascertained, beyond a shadow of doubt, that the strata in the Kladno-Schlan coal-field, in Central Bohemia, are divisible into precisely the same groups and follow the same sequence as those in the neighbouring Pilsen coal-field. The Kladno main seam, 23 feet thick, at the base of the lowest division, which consists of a complex of grey sandstones, with here and there conglomerates and dark shales, 1,000 feet in thickness, corresponds to the Farewell (Radnitz) seam of the Pilsen basin. Above the grey sandstones in both areas comes the Red Shale group, at least 500 feet thick. The Roof or Schlan seam probably belongs to the Grey Shale group, for the Red Rocks prove everywhere to be barren, and they are not met with in the shafts which have struck the coal. Farther west, the Schlan seam becomes known as the Kounova seam, and is evidently identical with the seam which occurs at the base of the Grey Shale group of the Pilsen coal-field.

In conclusion, it is pointed out that the *Stegocephalus*-fauna described by Prof. Fritsch from the Bohemian coal-bearing areas is not of Permian, but of Upper Carboniferous age. L. L. B.

GEOLOGY OF THE KLADNO-RAKONITZ COAL-BASIN, BOHEMIA.

Geologische Skizze des Kladno-Rakonitzer Kohlenbeckens. *By* Dr. K. A. WEITHOFER. *Verhandlungen der kaiserlich-königlichen geologischen Reichsanstalt*, 1902, *pages* 399-420.

The lowest group of the Coal-measure series in this field consists mainly of grey grits, often coarsening into conglomerates, and characterized near their base by the occurrence of coal-seams homologous with the lowest seams of the Pilsen coal-field, among them being the Kladno Main seam. These "Grey Sandstones" or "Pilsen-Kladno" beds reach a maximum thickness of 1,300 feet and a maximum breadth of outcrop of 2 miles.

Next above these come the Lower Red Shales or Teinitzl beds, 800 feet or so thick at most, which in turn are overlain by the Dark Grey Shales or Schlan beds. The last-named are thought to exceed 650 feet in thickness, and they contain the top seam of the coal-field, called also the Schlan seam after that locality.

Satisfactory evidence has now accumulated of the existence, above the foregoing groups, of the Upper Red Shales or Lihn beds, which are to be correlated with the equivalent barren group in the Pilsen coal-field.

The author draws attention to the remarkable parallelism of the succession of alternating grey (and coal-bearing) and red (and barren) groups in Bohemia, Silesia, Saxony, Moravia, and the Saare basin. The vast area over which the uppermost Carboniferous and the succeeding Permian deposits are seen to present the same characters, is indeed striking. What may be called the key-zone, on account of its persistent recurrence at the same horizon right away from Silesia into Lorraine, is the felspathic arkose belonging to the Middle Ottweiler beds and containing remains of conifers (*Araucarites*). The source of its materials appears to have been the granite-and-gneiss massif of Bohemia, and it was possibly formed under

desert-conditions, certainly not under the climatic conditions usually postulated in regard to the Coal-measures. A curious point, moreover, is that remains of aquatic organisms are so far unfindable in the rocks described in this paper, except in immediate association with the coal-seams. Whence the author marches to the still bolder conclusion that practically the whole of this red and grey Coal-measure series represents æolian deposits formed in a vast region of steppes. Much detailed evidence is adduced in support of this contention.

The paper does not profess to deal with the mining industry of the Kladno-Rakonitz area, but in many cases the author mentions mines as being no longer worked. L. L. B.

THE STRATIGRAPHY OF THE CENTRAL BOHEMIAN COAL-BASINS.

Zur Kenntnis der geologischen Verhältnisse der Mittelböhmischen Steinkohlenbecken. By CYRILL RITTER VON PURKYNĚ. *Verhandlungen der kaiserlich-königlichen geologischen Reichsanstalt*, 1902, *pages* 122-125.

The strata in the Pilsen coal-field, especially in that portion of it which lies south of the Mies river, are disturbed by a deep trough-like depression running nearly due north and south, and attaining in its central portion depths of 2,000 to 2,600 feet, but shallowing in a step-like fashion eastward and westward. Dr. Weithofer, who was the first to describe this, also drew attention to the repetition of two groups of barren Red Measures respectively overlying the two groups of productive Grey Measures. This sequence is again proved by the deep boring lately put down north of Liehn, which gave a greater thickness for the Pilsen Coal-measures than any yet known in that area. From above downward we have: 500 feet of red and mottled marls and sandstones; 590 feet of grey marl-slates and grey and white sandstones (arkoses), with one seam and other traces of coal; 170 feet of red and mottled marl-slates and arkoses; 1,380 feet of grey and white arkoses and grey clay-slates, with nine coal-seams in the lowest portion; these are underlain by Huronian slates, at a depth of about 2,640 feet from the surface. The same section is shown by nearly all the other deep borings in the coal-field, and as the basin gradually shallows eastward and westward, the topmost group of strata and then successively the others disappear. So it is that the coal-shafts at Nýřan and Mantau in the west, equally with those at Sulkov and Lititz in the south-east, only go through the lowest group of Coal-measures. So too did it come about that mining-engineers in the 'seventies and 'eighties confused the lower with the upper barren Red Measures, regarding them as one-and-the-same group.

After discussing certain stratigraphical points in some detail, the author recommends the following nomenclature as applicable to both the Kladno-Schlan and the Pilsen coal-basins:—(1) Nýřan-Radnitz Series, comprising both the lower groups; and (2) Kounowa Series, comprising the two upper groups. L. L. B.

COAL IN DIABASE AT RADOTIN, BOHEMIA.

(1) *Das Vorkommen von Kohle im Diabas von Radotin. By* DR. W. PETRASCHECK. *Verhandlungen der kaiserlich-königlichen geologischen Reichsanstalt*, 1902, *pages* 55-57.

In the Radotin Valley, south-west of Prague, is a sill of diabase intercalated among the Lower Silurian graptolithic shales, and containing an-

thracitic coal. Many observers, during the last thirty years or so, have attempted to account for this occurrence; and, after a brief criticism of their explanations, the author points out that the coal is, chemically and physically undoubtedly an anthracite; that there are inclusions of it, as as big as a man's head, within the diabase, surrounded by a layer of highly decomposed diabase; that similar coal occurs in the calcitic fissure-veins which traverse the igneous rock; that the coal is evidently of later origin than the zeolites and calcite with which it is associated; that carbon in the shape of bitumen was brought by means of percolating waters from the overlying (highly fossiliferous and bituminous) shales into the fissures of the diabase; and that this precipitated carbon was gradually metamorphosed into anthracite. Similar occurrences of coal within igneous masses are recorded from other localities in Bohemia, and the author agrees with Dr. Katzer in assigning them to the same cause as that just explained.

L. L. B.

(2) *Zur Frage der Kohle im Diabas von Radotin.* *By* F. SLAVIK. *Verhandlungen der kaiserlich-königlichen geologischen Reichsanstalt*, 1902, *pages* 194-196.

There has been of late some controversy regarding the genesis of the [Silurian?] anthracites of Central Bohemia. Some of these have been found completely included within masses of eruptive diabase at various localities besides that mentioned in the title of this paper Hodkovičky, Řeporeje, Zabehlic, etc.).

Various writers have held that these anthracites are the fragmentary remains of true Coal-measures which have been utterly swept away by subsequent denudation. Dr. Petrascheck, on the other hand, regards them as derived from the bituminous and highly fossiliferous Upper Silurian limestones; but the present author will only admit this to be undoubtedly true of such anthracitic coals as occur encrusted with calcspar as infillings of fissures in the limestones. He points out the probability that the coal enclosed in the eruptive rocks of Radotin and other localities was brought along by the molten mass as it tore its way up through the Silurian and pre-Cambrian sedimentaries. In later times, in cases where the diabase was subjected to the decomposing action of weathering agencies, the carbonaceous particles would tend to concentrate in certain fissures, of which they would form the infilling, together with such minerals as calcite and zeolite.

L. L. B.

THE BROWN-COAL DEPOSITS OF NORTHERN BOHEMIA.

Ueber die Lagerungs- und Altersverhältnisse einiger Glieder der Nordböhmischen Braunkohlenablagerungen. *By* J. E. HIBSCH. *Jahrbuch der kaiserlich-königlichen geologischen Reichsanstalt*, 1901, *vol. li.*, *pages* 87-92.

As far as the Teplitz coal-field is concerned, at all events, the author's recent researches have convinced him that Prof. C. F. Naumann's view of the age of the brown-coal deposits, published in 1866, but since then generally disputed, is after all correct. That is, the brown coals, whether associated with the eruptive basalts and tuffs, or with the clays and sands containing quartzite-concretions below them, belong to one-and-the-same geological period, the Upper Oligocene and not to the Miocene. He tabulates the rock-succession as follows (in descending order):—

Periods.	Within the volcanic area of the Mittelgebirge.	In the Coal-basin west and north of the volcanic Mittelgebirge.
Lower Miocene.	Latest eruptive rocks. Fresh-water limestone of Kostenblatt.	Fresh-water limestone of Tuchorschitz, etc.
Upper Oligocene.	Eruptives and accompanying tuffs. Tuffite, clays, combustible shales. Brown coal-seam of Lukowitz, etc. Diatomaceous shales, tuffite.	Fire-clays of Preschen combustible coaly shales. Roof-beds (clays, shales, and sands). Brown coal-seam. Floor (mottled clays, in part).
Middle Oligocene.	Clays, sands, and sandstones, quartzite-blocks.	Mottled clays, in part. Sands, sandstones, and quartzite-blocks.
Upper Turonian.	Marl with *Inoceramus Cuvieri*, Sow.	

The so-called "brown coal-seam" is really split by thin partings into several seams, but the partings represent a very insignificant thickness in comparison with the enormous mass of the coal. Most of the few fossils found in it are plant-remains, but the Preschen fire-clays (from 200 to 500 feet above the coal) are rich in characteristic fossils. The brown coal is often broken through not only by basalts, but also by phonolites and trachytes, and at those points is of course considerably altered. L. L. B.

NICKEL-ORE DEPOSITS ON THE SAXON-BOHEMIAN FRONTIER.

Ueber eine neue Nickelerzlagerstätte in Sachsen. By Dr. R. Beck. *Zeitschrift für praktische Geologie*, 1902, *vol. x.*, *pages* 41-43.

In the first place, the author recalls his recent description of the nickel-ore which occurs along the salband of a diabase-dyke at Schweidrich in North-eastern Bohemia, and then states that towards the end of 1900, a similar occurrence was reported from Aeusserstmittelsohland, south of Schirgiswalde, exactly astride of the boundary between Saxony and Bohemia.

Geologically, the region is defined as that of the Lausitz granite, the vast mass of which is seamed by numerous diabase-dykes. The vertical section shown by a trial-shaft put down in the Sohland valley, is, in descending order, as follows:—Granite-rubble 10 feet; and ferruginous gossan passing downward into diabasic rock impregnated with sulphidic ores, 24 to 26 feet. Two trial-headings, 7 feet long, have been driven eastward and westward from the shaft-bottom and are completely within the ore-body.

The gossan consists chiefly of brown iron-ore, with irregular masses of black copper-ore and light-green strings of malachite, disseminated among the débris of decomposed diabase.

Lower down, come the copper-pyrites and nickeliferous magnetic

pyrites, very irregularly impregnated the diabasic rock: sometimes, however, they form fairly-large separate aggregates. The author saw, for instance, quite pure magnetic pyrites in nodules as big as a man's fist. The percentage of nickel is considerable, quite sufficient at all events to justify methodical working of the deposit. Actual analyses of the ore are, however, at present withheld from publication. The ore-bearing rock is a variety new to Saxony, and is described as a hornblende-olivine diabase, rich in spinel and biotite, and of gabbro-like habit. The mineral which was first to crystallize out was the dark-green transparent spinel: this was succeeded by the olivine, and that by the pyroxene and the hornblende. The crystals of these last two minerals are not seldom corroded, and in such a case are enclosed by bands or borders of pyrites, the ore appearing to dovetail into the crystal. The pyrites also occurs within the serpentinized olivines, or is closely intergrown with the biotite-crystals. The obvious conclusion is that the metalliferous ores are the latest-formed constituents of the rock. No room for doubt remains that the Schweidrich and Aeusserstmittelsohland deposits are genetically connected; and, further, they present an unmistakable analogy to the nickel-ore deposits of Norway, Piedmont and Canada. L. L. B.

ALLUVIAL GOLD IN BOSNIA.

Ueber die Zusammensetzung einer Goldseife in Bosnien. *By* Dr. Friedrich Katzer. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1901, *vol. xlix., pages* 277-280.

The gold-bearing alluvial deposits in the Pavlovac stream are near the town of Fojnica in Bosnia. There are traces of glacier-action in the neighbourhood, and it is probable that the deposits were originally due to the grinding effect of the ice. In some places they are rich in gold. One man in three days obtained 15 grains by washing the sand, and nuggets larger than a pea have occasionally been found. Waste-heaps where gold was formerly washed, and remains of old diggings can still be traced by the side of the stream, and may contain a little gold. Deposits of a later age, about 6½ feet thick, stretch on either bank, and fill up the inequalities of the river-bed.

Two samples of the soil were taken from different places, mixed, and sent to the chemical laboratory at Sarajevo to be tested. Of these 55 pounds were dried in the air, passed through a sieve, and sorted into eight different sizes, from pieces larger than an egg to grains $\frac{1}{50}$ inch in diameter. The two finest kinds were washed, and in the process two little pellets of gold weighing 0·14 grain were found in them. The sample was then freed from iron and other foreign substances, and classified into:—Coarse pebbles of micaceous-schist veined with milky quartz, a piece of silver-bearing lead-slag, showing marks of a peculiar smelting process, iron-slag, gœthite, mica-peroles such as are found throughout the district, and refined lead containing silver.

A weight of 220 pounds of the alluvial deposit was found to contain 0·0376 gramme of gold, and a large percentage of mica, besides red hæmatite, magnetite, and gœthite. The slag shows that there were formerly smelting works in the district, although nothing is known of them. Silver and copper must have been worked, for the ores are still here. There is also brown iron-ore, which was till recently smelted in the furnaces at Fojnica.

Iron-slag has been found at a considerable elevation, and as no water-power to drive the furnaces was available, they must have been worked by man-power only, or by utilizing the pressure of the wind. Much of the iron-ore in Bosnia is so pure that it was deposited, probably, long before the other metals.

Next to mica, gœthite is most conspicuous in the Pavlovac deposits, and seems to have been originally pyrites, converted into gœthite in its progress down the valley. Magnetite is another noticeable feature of this deposit, and is found as crystals in the mica. Its frequent presence in these gold-bearing deposits is interesting, because it confirms the well-known geological theory that magnetite usually accompanies alluvial gold, and in Bosnia it is even regarded as a kind of indicator, pointing to the existence of the gold.

The origin of the gold found throughout the district has not been explained. Some connection may exist between it and the magnetite, or it may be derived from iron-pyrites or grey copper. The pyrites of a neighbouring district is comparatively rich in gold, and elsewhere in Bosnia grey copper containing gold is found. E. M. D.

COAL IN THE TRIAS OF BOSNIA.

Ueber ein Kohlenvorkommen in den Werfener Schichten Bosniens. By FRIEDRICH KATZER. *Centralblatt für Mineralogie, Geologie und Palæontologie*, 1902, *vol. ii., pages* 9-10.

The coal occurs as a very thin seam in sandstones belonging to the Werfen stage of the Trias, near the village of Lepovići north of the famous iron-ore mines of Varesh. No plant-remains or other fossils have been found in the neighbouring beds, so far; the strata dip almost vertically southward (80 degrees), and strike west-north-west. The coal, when dried in the air, crumbles up easily; it is black, with a lustrous conchoidal fracture, and dark-brown streak. It ignites with difficulty, burns with a short non-luminous flame, and leaves a great deal of reddish-grey ash. The latter, under the microscope, is seen to contain, besides its aluminous and iron oxide constituents, fragments of quartz and mica. The percentage of ash is 16·04, of volatile constituents 6·48, and of hygroscopic water 8·23. The calorific power, estimated by the Berthier method, is 4,256 calories. The mineral contains some sulphur, and does not coke.

The deposit is, unfortunately, of no industrial importance.

L. L. B.

THE IRON-ORE DEPOSITS OF HÜTTENBERG, CARINTHIA.

Der Erzberg bei Hüttenberg in Kärnten. By BRUNO BAUMGÄRTEL. *Jahrbuch der kaiserlich-königlichen geologischen Reichsanstalt*, 1902, *vol. lii., pages* 219-244, *with* 19 *figures in the text and* 2 *plates.*

The Erzberg (Ore-hill) at Hüttenberg in the north-eastern district of Carinthia has been the object of active mining industry since the days of the Romans, and its mineral wealth is by no means exhausted yet. The hill in question forms the extremity of a westerly spur jutting out from the mountain-range of the Grosse Saualpe, which itself trends north and south. As much discussion had arisen in regard to the genesis of the

ore-deposits, the author undertook in 1900 and 1901 a detailed petrographical study of the area, the fruits of which are now presented to the public. His paper is preceded by an elaborate bibliography, and before entering into the petrographical detail he gives a general sketch of the geology. The predominant rocks are schistose and banded, and used to be conveniently (if not too correctly) grouped all together as gneisses, there being a considerable mass of true gneiss among them. Intercalated among them are coarse-grained tourmaline-pegmatites and granular limestones; and with the main limestone-reef are chiefly associated the ore-deposits. The last-named, in a fresh condition, consist of granular aggregates of spathose iron-ore, often with pyrites as a secondary occurrence. Towards the outcrop the ore is weathered to brown hæmatite. Only occasionally are the iron-ores found to be intercalated among mica-schists, as the Bilbao miners' *dictum* "The limestone is the mother of the ore" appears to hold good in this district too. Taken as a whole, the metalliferous deposits form a stockwork, which exhibits no discernible relation whatever to the dip and strike of the bedded rocks: the ore-bodies are traversed by the tourmaline-pegmatite veins, and in fact these pegmatites appear to occur constantly in association with the iron-ores, but they are then kaolinized. The pegmatite-veins are undoubtedly intrusive, that is, of eruptive origin; and the author claims that, in contradistinction to the hitherto generally-accepted view that the Hüttenberg ores are a sedimentary deposit, it is to similar eruptive phenomena that the genesis of the ores can be traced back. He marshals at length the evidence which leads to this conclusion, his final statement being that the post-volcanic processes connected with the intrusion of a neighbouring granitic mass resulted in the partial replacement of limestone by iron-ores. L. L. B.

LEAD- AND ZINC-ORE DEPOSITS IN UPPER CARINTHIA.

Zur Kenntniss einiger Blei- und Zinkerzvorkommen der Alpinen Trias bei Dellach im Oberdrauthal. By OTTO SUSSMANN. *Jahrbuch der kaiserlich-königlichen geologischen Reichsanstalt*, 1901, *vol. li., pages* 265-300, *with* 5 *figures in the text and* 1 *plate.*

This elaborate memoir deals with the metalliferous mines of Kolm and Scheinitzen in the neighbourhood of Dellach (Upper Drave Valley), and with some isolated occurrences of ore near Pirkach. A short but adequate bibliography is followed by an historical sketch of the recently resuscitated mining industry in that region. Then comes a brief orographical description, and thereafter the stratigraphy and tectonics are considered in detail. Two parallel mountain-ranges run east-and-west, between the Gail and the Drave and the Möll and the Drave respectively; the rounded summits of the northernmost range belong to the old crystalline schists, while the bare serrated peaks and ridges of the southern range proclaim from afar the predominance of the Alpine Triassic limestones and dolomites. In fact, the river Drave in its westerly course may be regarded as demarcating the boundary between the two formations.

The older crystalline schists hereabouts are overlain by the Groden sandstones and conglomerates, of Permian age. These are succeeded by Triassic strata, of a facies which is more of the North than of the South Alpine type, and these in turn by the Rhætic. Jurassic, Cretaceous, and Tertiary formations are conspicuous by their absence, but deposits of glacial origin play an important part in the geology of the district.

The ore-deposits of Kolm and Scheinitzen occur in the Muschelkalk limestones, some beds of which are gypsiferous and others bituminous. The ores of the Hermann adit are in higher beds (Wetterstein limestone); those of the Pirknergraben near Pirkach are in the *Cardita*-beds, and the isolated ore-bodies of the Marchgraben occur in Rhætic limestone.

At Kolm, the ore is really of the nature of a bedded deposit, the workable beds occurring in the neighbourhood of fissures in the Muschelkalk which are locally termed "veins." Galena is the predominant ore, and has withstood the usual agents of decomposition more successfully than the others. Most of the zinc-blende has been altered into earthy calamine, while comparatively pure brown hæmatite occurs in great cavernous masses in the upper part of the deposit and is probably the decomposition-product of the marcasite. The ores within the fissures or "veins" themselves are of less industrial importance than those which impregnate the "country." At Scheinitzen, the ores are chiefly zinc-blende and galena, and this appears to be the case also in the Pirknergraben and the Marchgraben.

The genesis of the deposits is discussed at considerable length, and there appears to be little doubt that the primary agents in their formation were thermal waters which carried along with them metallic particles in solution. Local circumstances, as for instance the presence of the impervious Wengen beds which both at Kolm and Scheinitzen dammed back the thermal waters, preventing their further uprise through the strata, modified the ultimate characteristics of the ore-bodies without altogether masking their common and probably contemporaneous origin. L. L. B.

THE COAL-BEARING TRIAS OF UPPER LAIBACH, CARNIOLA.

Ueber die Lagerungsverhältnisse der kohlenführenden Raibler Schichten von Oberlaibach. *By* DR. FRANZ KOSSMAT. *Verhandlungen der kaiserlich-königlichen geologischen Reichsanstalt*, 1902, *pages* 150-162, *with* 6 *figures in the text.*

The existence of coal in the Middle Trias, north of Oberlaibach, has long been known, and the district has been the scene of repeated exploration-work. Now again, very careful investigations are being made, with the view of determining whether the deposits would repay working. The outcrops occur in a narrow ridge which separates the Horjul valley from that of Podlipa: the last-named valley opens out gradually into the plain of Oberlaibach.

A detailed synopsis of the rock-succession is given, from which it appears that the coal is practically confined to the Raibl group, a series (at the base) of dark limestones interbanded with highly-fossiliferous black shales and coal-seams, and (in the Podlipa valley) pisolitic ironstones. But the main mass of the group is made up of vividly-mottled crumbly clay-slates and sandstones. It is overlain by the Hauptdolomit, and underlain by the St. Cassian Limestones and Dolomites.

The coal of the Lower Raibl group is of drift-origin, that is, it originated in masses of plant-remains floated in among marine deposits from a not very distant shore-line.

A bore-hole, put down at Drenovgrič to a depth exceeding 1,490 feet, proved the thickness of the entire Raibl group to be about 1,250 feet. West of this locality a shaft proved two main coal-seams: one, some 20 inches thick, almost immediately above the St. Cassian Dolomite, and the other

(a double seam from 2 to 3 feet thick) separated from the former by a barren mass of limestone-and-dolomite breccia and crushed marl. The average dip of the bottom seam is high—60 to 70 degrees, and one gathers that the strata are sharply folded into anticlines and synclines, and complicated by faults. Although the coal does not seem to lie anywhere at what we should consider great depths below the surface, the water from the overlying dolomite (held up by the impervious Raibl Series) constitutes a serious obstacle to mining enterprise. The coal is characterized as an anthracite, with a calorific power of 6,655 calories. It yields as much as 10·4 per cent. of ash, and pyritous impurities are not uncommon.

The pisolitic hæmatite already mentioned as occurring in the Podlipa valley would hardly repay working. L. L. B.

BORINGS FOR PETROLEUM IN HUNGARY.

(1) *Ueber die Aussichten der Petroleumschürfungen im Thale des Laborecflusses bei Radvany (in Oberungarn).* By DR. STANISLAUS OLSZEWSKI. *Zeitschrift für praktische Geologie*, 1901, *vol. ix., pages* 353-356.

The author went specially to the neighbourhood of Csebinye and Radvany in county Zemplin, with the express view of ascertaining whether the geological structure of the district would warrant a systematic exploration for petroleum.

He describes the strata in detail, but appears to differ fundamentally from the officers of the Hungarian Geological Survey, in the age, which he assigns to them. He says that they all belong to the formation known in Galicia as the Saliferous Clay or Upper Oligocene. The Royal Hungarian Survey on the other hand, groups them as Magura Sandstone (Upper Cretaceous and Eocene), underlain by the Cretaceous Smilno and Belovesza shales, and the Neocomian Ropianka beds. He controverts emphatically the generally-received opinion that the natural oil observed in the neighbourhood of Radvany occurs in a belt which is practically the continuation of the petroliferous Ropianka beds near Dukla in Galicia. The difference of age is enormous, and moreover the strata of the Hungarian-Galician frontier strike across the strata of the Laborec valley (Radvany). Nevertheless, he does not deny that the district of Radvany has all the character of an oil-field, and though the boring, put down by an Austro-Belgian syndicate to a depth of 1,748 feet, was undertaken at a badly-chosen spot, it struck oil twice, but in small quantity.

By a detailed comparison of the Galician sequence with that around Radvany, the author concludes that oil in payable quantities will be found at much greater depths. He considers that it would be advisable for the Hungarian Government to give financial support to those who would undertake a boring to a depth of 4,000 feet or so, and he points out that the technical advance in the science of boring is so great that such an enterprise would be quite practicable. In Galicia borings of fairly large diameter are easily carried down to depths of 2,500 feet or more.

L. L. B.

(2) *Geologische Aufnahmen im Interesse von Petroleum-Schürfungen in den Comitaten Zemplén und Sáros.* By KOLOMAN VON ADDA. *Mittheilungen aus dem Jahrbuche der königlich Ungarischen Geologischen Anstalt*, 1902, *vol. xiii., pages* 145-198, *with* 1 *figure in the text and* 1 *plate.*

The author examined the area described in this memoir, on behalf of the

Hungarian Government, in his capacity as geological surveyor, in 1898. As that portion of the Magyar kingdom borders on Galicia, one of the problems that awaited solution was, whether the oil-bearing beds continue (in common with certain other formations) from Galicia into Hungary.

The general rock-succession is, in the first place, described as being (in ascending order):—(1) Lower, Middle, and Upper Eocene (mottled shales, sandstones, marls, etc.); (2) Lower, Middle, and Upper Oligocene (shales, sandstones, etc.); and (3) Quaternary alluvial formations. A detailed account is then given of the stratigraphy of the neighbourhood of Rokitócz, Zemplén-Driesna, and Sáros-Driesna, Alsö-Komarnik and Felsö-Komarnik.

With regard to the Rokitócz district, the author considers that a deep boring going down not less than 2,000 feet would strike the oil-bearing Lower Eocene, the Oligocene formation being there comparatively thin. In the neighbourhood of the two Driesnas the strata have the undulatory character which is the primary condition of the existence of a natural oil-reservoir, and, taking all the tectonic circumstances into account, a boring should yield successful results. The strata through which it should be put down, however, are restricted to a very small area and dip very steeply, nor do they occur in a particularly accessible spot. The remaining area of the Driesna district is not favourable for oil-prospecting. At Felsö-Komarnik, the Lower Eocene strata form the south-easterly prolongation of the rich petroleum-belt of Galicia: they cover here, it is true, but a small surface, though very promising for the oil-prospector. The best locality for a boring would be the area east of the confluence of the Dolina with the streamlets which run down from the Banchora range: the operations would have to be carried down to a minimum depth of 2,100 feet. A boring which was put down 1½ miles north-west of Barwinek, struck a little oil at the depth of 1,770 feet, and this was associated with violent outbursts of natural gas. L. L. B.

(3) *Petroleumschürfungen in Ungarn im Jahre* 1900. *By* A. WALTHER. *Földtani Közlöny*, 1902, *vol. xxxii., page* 154.

At Luch, in Ungh county, three bore-holes were put down. One, the Anna bore-hole, struck oil at a depth of 1,033 feet from the surface; the bore-hole was continued some 300 feet farther, when it was found that (accidentally) a trespass had been thereby committed on a neighbouring property, and further operations were suspended. The Török bore-hole reached a depth of 2,380 feet, but the diameter of the bore-hole had by that time contracted to such an extent that in this case also further work was stopped. The Lidia bore-hole was a more successful undertaking: oil was struck at a depth of 758 feet, and by December, 1900, 5 barrels of crude oil were being got thence daily.

At Felsö-Komarnik, in Sáros county, a boring reached on January 23rd, 1900, a depth of 2,083 feet from the surface. Oil and gas had burst forth 300 feet or so before this depth was reached, but after some weeks' pumping the supply gave out; and, the boring being thereupon carried down to the depth previously mentioned, another petroleum-reservoir was tapped which yielded regularly 5 barrels per day throughout the year.

Certain outbursts of gas and oil took place in the Izbugya-Radvány bore-hole, in county Zemplén, at the respective depths of 928 and 1,056 feet, but boring was being carried deeper down and operations were still in progress at the end of 1900. L. L. B.

THE JASZTRABJE PYRITES-DEPOSIT, HUNGARY.

Über ein Schwefelkieslager bei Jasztrabje in Ungarn. By J. KNETT. *Zeitschrift für praktische Geologie*, 1903, *vol. xi., pages* 106-110, *with* 4 *figures in the text.*

The lowlands of Nagy-Tapolcsan, known chiefly as a brown-coal basin, are the site of a Tertiary gulf, bordered to the westward by highlands of crystalline schist, and to the northward by the dolomite-hills. At the north-western head of this ancient gulf the author examined a deposit of pyrites about 20 inches thick in black clay, laid open by a railway drainage-cutting near Jasztrabje. The ore does not form a compact mass, but is rather cavernous in appearance (that is, contains large cavities), and the author is understood to suggest that it was deposited at the same time as the black clay and is to be associated with the decomposition of vegetable matter *in situ* in a swampy area. The strata, at one time horizontal, have now been folded into an anticline.

The ore-deposits would undoubtedly repay working, and points are suggested where it might be advisable to put down an exploration-shaft, with the view of determining the actual extent of the deposit. The area can hardly be very considerable, as the anticline is brought up sharply against the crystalline schists on the one hand, and against the Cretaceous dolomites on the other, but the possibility of a south-easterly extension is not excluded. Exploration-work might have the additional advantage of proving further occurrences of brown coal. L. L. B.

POLYHALITE IN THE AUSTRIAN SALT-DISTRICT.

Ueber die Polyhalite der Alpinen Salzberge. By AUGUST AIGNER. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1901, *vol. xlix., pages* 686-689, *with* 2 *figures in the text.*

Polyhalite forms an important characteristic of the rocks in this district. Although it does not vary much in composition, yet if considered in relation to the other rocks of the country, much light is thrown upon its origin. It occurs in three forms, the columnar, the foliated, and as red anhydrite.

In the first it is found in fragments from ¼ to 4 inches thick, and its chemical formula is $2CaSO_4,MgSO_4,K_2SO_4,2H_2O$. It is flesh-coloured, shading into brick-red, and has a pale resinous lustre. The little rods are always twisted, and their edges overlain with clay. This fragmentary crystalline polyhalite is usually scattered throughout the saliferous clay, but sometimes rests directly upon the salt-rock, upon which it must have been originally deposited as a sediment. The stratum is not very thick and follows the variations of that below it. If the polyhalite is dissolved artificially, as often happens in salt-mining, beautiful lumps of this crystallized anhydrite appear. Two samples from Hallstadt were analysed, and their chief constituents were calcium and 50 per cent. of sulphuric acid. Glauberite from Ischl showed a similar chemical composition.

The second form of polyhalite, the foliated, is found in conjunction with crystals of brown anhydrite. It is a beautiful dark red, and was at first supposed to be glauberite, but the writer proves the difference between them by comparing the chemical analyses of the two substances. Glauberite is another form of polyhalite, contains the sulphates of soda and lime, and is much richer in potash.

The third form of polyhalite is the red anhydrite. In the salt-district it is always found in grains, of a paler red than the columnar or foliated

varieties, and is probably a grey anhydrite, impregnated with polyhalitic salt, or rather an anhydrite which has been deposited in a solution of polyhalite. The red anhydrite occurs in such quantities at Aussee that it is used as manure. It contains much less potash and magnesia than the other two forms, but a large percentage of chloride of soda, or common salt, and this constitutes its value as manure. E. M. D.

METAMORPHISM OF THE GRAPHITE-BEDS IN UPPER STYRIA.

Der Metamorphismus der Obersteierischen Graphitlagerstätten. By DR. K. A. REDLICH. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1901, *vol. xlix.*, *pages* 403-404.

The graphite-beds are now recognized as being of sedimentary origin, since the discovery in them of a Carboniferous flora. The writer discusses the question whether the present form of the carbon is due to dynamic metamorphism, or to contact with volcanic rock. There are two varieties of graphite, the soft and the hard. The first, according to Dr. Weinschenk, originated during great structural disturbance of the rocks, and has been crushed like coal by the pressure. The hard graphite may be compared to coal converted into coke, and brought in contact with volcanic rock; the one is the result of dynamic, the other of volcanic action.

The writer inspected the graphite-beds in the conglomerate at Sunk in Upper Styria: they are sometimes soft and foliated, sometimes hard and crystalline, chiefly the latter where the strata are much contorted. In the Bernese Oberland, the Jura, and the Styrian Alps the whole of the limestone, gneiss, and other rocks have not been subjected to transformation. Many of the Mesozoic limestones, in spite of the pressure, have preserved their original tough character, while others show crystalline structure in places where no volcanic influence is possible. Sometimes the strata have been exposed to the greatest pressures, without losing their characteristics, and the carbon has not been metamorphosed into crystalline graphite. Near Leoben there are two beds of graphite-slate. One of them lies directly upon the "white stone" which in its turn rests on the gneiss, the dividing line being sharply defined. The other is separated from it by a bed of micaceous schist, containing many fossils, and upon neither can the gneiss have acted in the way supposed. Below the graphite is a bed of serpentine embedded in the conglomerate, and it would be interesting to know what effect has been produced by it upon the graphite. E. M. D.

COAL IN THE TRIAS OF SOUTHERN TYROL.

Ueber ein Kohlenvorkommen in den Wengener Schichten der Südtiroler Trias. By COUNT H. KEYSERLING. *Verhandlungen der kaiserlich-königlichen geologischen Reichsanstalt*, 1902, *pages* 57-61, *with 2 figures in the text.*

The locality of this occurrence, visited by the author in the autumn of 1901, is on the south-eastern slope of Monte Coldai, in the Civetta range, at a point near the junction of the Wengen tuffs with the Wengen dolomite. The former strata are much disturbed and faulted, and the main coal-seam crops out at an altitude of 5,350 feet, about 300 feet north of the disturbance. The main seam varies in thickness from 15 to 20 inches, dips 20 degrees south-south-eastward, and has a floor of dark limestone, but

in some places it is interbedded with clays and sandstones. The mineral is highly pyritous, and the author thinks that it is the outcome of the carbonization and decomposition of a layer of aquatic plants. He found similar coal-seams in the dolomite, and suggests that the currents bearing nutritive matter which encouraged the reef-building organisms (corals, calcareous algæ, etc.) to settle on that portion of the Triassic sea-floor, also floated thither the decomposing aquatic plants. The submarine volcanic eruptions, characteristic of the Wengen period, may have played some part in the carbonization, impregnating the plant-remains with sulphidic solutions.

The inhabitants of the neighbouring valleys had conceived rather extravagant hopes concerning these coal-seams, but it is now quite evident that the occurrence is not of industrial importance. L. L. B.

THE SCHNEEBERG ORE-DEPOSITS, TYROL.

Die Erzlagerstätte des Schneeberges in Tirol, und ihr Verhältnis zu jener des Silberberges bei Bodenmais im Bayrischen Wald. By E. WEINSCHENK. *Zeitschrift für praktische Geologie*, 1903, *vol. xi., pages* 231-237.

Sulphidic lead and zinc-ores are of widespread occurrence, especially in the Eastern Alps, among the crystalline schists which mantle over the central granite-core. On the whole, however, the ore-deposits are too poor, and the transport-facilities are too restricted to admit of successful working. Thus it is that mines in the western part of the Eastern Alps have mostly long since been abandoned, while in the eastern part of that mountain-region many are still actively at work. Among the ore-occurrences known in the Tyrol, the Schneeberg deposit is one, the genesis of which has long formed the subject of more or less acrimonious discussion. The detailed investigations of Prof. Elterlein have shown that the Schneeberg ore is really of the nature of a vein-deposit. In this conclusion, the author emphatically concurs, but the main object of his paper is to refute the supposed analogy between the ore-deposits of Silberberg, near Bodenmais, in the Bavarian Forest, and those of Schneeberg. One of the peculiarities of the last-named is the occurrence of garnet, quartz, hornblende and mica, with chlorite, apatite and titanite, either in the form of nests within a normal sulphidic zinc-lead mass (blende, galena, iron-pyrites, magnetic pyrites, mispickel, boulangerite and fahlore), or sometimes mixed to a slight extent with the ore-body. The author regards the Silberberg deposit as having originated in a pyritic magma which welled up from great depths, and he refutes at some length Prof. Beck's objections to this hypothesis, declaring that further study of the local conditions has confirmed him in his original opinion. The Schneeberg deposit, on the other hand, is a normal vein of the Clausthal type. L. L. B.

THE ORIGIN OF THE MARBLES OF THE TYROL.

Die Tiroler Marmorlager. By E. WEINSCHENK. *Zeitschrift für praktische Geologie*, 1903, *vol. xi., pages* 131-147, *with 2 figures in the text.*

The author reminds us in the first instance of Prof. Vogt's researches on the connection between the genesis of marble and its structure. That able writer distinguished between those varieties which are of contact-meta-

morphic origin, and those which are of dynamo-metamorphic or regional-metamorphic origin, concluding that the varieties which may be ranged in the first category are generally useless for ornamental purposes, as they are not sufficiently durable. The author's first-hand knowledge of Alpine marble-deposits led him to doubt the soundness, or at any rate the universal applicability, of Prof. Vogt's conclusions. He points out that much of the Carrara marble, the use of which is world-wide, exhibits the rectilinear granular structure typical of a contact-metamorphic origin.

He describes in great detail the chief occurrences of workable marble in the Tyrol, and shows that these were originally Palæozoic or Mesozoic fossiliferous limestones, through the massive beds of which basic eruptive magmas (near to gabbro in composition) tore their way, probably reducing the whole mass to a pasty semi-liquid condition, and therewith setting up all sorts of chemical reactions which in part explain the metamorphism of the sedimentary deposits into marbles and schists.

The important conclusion to be drawn from the economic point of view, is that the Tyrol marbles, both in structure and in mineralogical composition, are the result of intense contact-metamorphism. Contact-metamorphic marbles are of excellent quality, ranking indeed among the best known to commerce, and thus Prof. Vogt's interpretation of the connection between the structure and genesis of marble fails to hold the field.

L. L. B.

THE CAMPINE COAL-FIELD OF NORTHERN BELGIUM.

(1) *Quelques Mots à propos du Sondage d'Asch.* *By* BARON OCT. VAN ERTBORN. *Bulletin de la Société Belge de Géologie, de Paléontologie et d'Hydrologie*, 1901, *vol. xv., Procès-verbaux, pages* 593-595.

Towards the end of August, 1901, the announcement was made that this boring had struck several seams of coal. It now appears that the Coal-measures were reached at a depth of 1,705 feet from the surface (or 1,440 feet below sea-level), that is, only about 33 feet deeper than might have been predicted from a general consideration of the geology of the country. The 1,705 feet of barren strata are made up of 558 feet of Cretaceous and 1,147 feet of Tertiary rocks, among which latter are several horizons of loose sands and some water-bearing sands. The Cretaceous is probably fissured here and there, but on the whole the conditions of the great mass of strata overlying the Coal-measures at Asch are not so unfavourable to industrial enterprise as might appear at first sight.

(2) *Études sur le Bassin houiller du Nord de la Belgique.* *By* X. STAINIER. *Bulletin de la Société Belge de Géologie, de Paléontologie et d'Hydrologie*, 1902, *vol. xvi., Mémoires, pages* 77-120, *with* 3 *figures in the text and* 1 *plate.*

One point of considerable importance in connection with the new coal-field, in the Belgian province of Limburg, is that the seams already proved, though very rich, lie beneath so great a thickness of younger strata that their full value cannot be got out of them at present. It would be highly desirable to trace out a further extension of the coal-field, and there possibly the seams might be reached nearer the surface. In order to help to the attainment of this object, the author has studied the solution of those problems (associated with the new coal-field) that appear to him of the most immediate practical interest.

The author shows that the new coal-field is a prolongation of those of

Liége, Dutch Limburg, and the Wurm basin. The Lower Carboniferous massif of Visé can no longer be regarded as the northern boundary of the Liége basin: it is simply an islet surrounded on all sides by Coal-measures. It seems probable that the Lanaeken limestone is a similar islet, but that it marks the south-eastern border of the coal-field of Belgian Limburg. The coal-seams in this probably belong to a higher horizon than those in Dutch Limburg, one reason for the supposition being that they are much richer in volatile constituents. The amount of volatile constituents in coal is not, however, an infallible guide as to its relative horizon in the series.

The present distribution and localization of the Coal-measure massifs of western Europe and Britain is a result of the Hercynian crust-foldings (as was shown by Prof. Suess). That fact being conceded, it is possible to plot out, as the present author does, the areas along which Coal-measures may be looked for, from Aix-la-Chapelle to South Wales, and from Westphalia to Lanarkshire. The stratigraphical phenomena to which the Hercynian folds and subsequent cross-folds have given rise, and the consequent positions of the British and other North-west European coal-fields, are sketched by the author in some detail. He then proceeds to consider, in the light of these facts, the probable extent of the new Belgian coal-field. It may be expected to occupy an irregular triangle, considerably drawn out from east to west. He does not think that it will be traced beyond the Scheldt in Belgian territory, and the industrially-useful portion of the Coal-measures in the province of Antwerp will probably be confined to the north-eastern moiety thereof.

A good deal of mystery surrounds the new borings and trial-sinkings, and information as to the results achieved has only been obtainable privately, and then in a very meagre fashion. Piecing together the scattered fragments of information that he has been able to collect the author finds that the new Belgian coal-field is comparable in its general features with those of Shropshire and Southern Staffordshire, which lie on the northern border of the same anticline and like it overlie unconformably the Silurian. All these basins are of the lymnic (swamp, freshwater, or continental) type. The measures are apparently very regular, the dip is not steep, and the general strike is east and west. The seams are not very numerous, but in the matter of volatile constituents they differ from 18 to 44 per cent., and a seam of cannel-coal was struck in one of the first borings. The grey grits resemble closely those in the uppermost Coal-measures of England, which pass up into the red rocks that used to be considered as Permian. The boring at Eelen in the north of Limburg, at a depth of 2,034 feet, struck red sandstones, which continued down to 2,912 feet. These sandstones the author now regards as being either Permian, or of Upper Coal-measure age. If they are Permian, the salt-bearing beds of the Zechstein should be struck farther north, and thus Belgium would possess a salt-field as well as a new coal-field.

In an appendix, the author enumerates the proofs of an easterly extension of the British coal-fields, and in another appendix the proofs as to a north-westerly extension of the Westphalian coal-field.

(3) *La Houille en Campine.* *By* M. Lohest;

(4) *Raccordement du Bassin Houiller de la Campine avec celui de la Westphalie.* *By* A. Habets;

(5) *Précisions relatives à l'Epaisseur et à la Nature des Morts-terrains, en Campine.* *By* H. Forir; *and*

(6) *Richesses minières domaniales en perspective.* *By* ÉMILE HARZÉ; *Annales de la Société Géologique de Belgique*, 1902, *vol. xxix., Mémoires, pages* 81-119, *with* 2 *figures in the text and* 1 *plate.*

In accordance with the predictions of the geologists, coal has been struck in the Campine district, north of the Liége basin. In the neighbourhood of Asch, about ten different borings have reached the Coal-measures, after passing through some 1,600 feet of barren strata. The seams are very rich in volatile matter, and their general tendency to flatten out seems to indicate that one is here in the central part of a basin. Analysis of the coal shows that it is comparable to the coals richest in gas of the Mons basin. Premising that in a group of Coal-measures the gaseous seams are generally the uppermost, and that the depth and width of a coal-basin are proportionate to the richness in volatile matter of the seams which it contains, the first author infers that the newly-discovered basin is as deep as that of Mons (where the Coal-measures exceed 9,000 feet in thickness). He thinks that it is probably more extensive, for the synclinal folds in Belgium are broader the farther north they lie from the Ardenne axis of uplift; and so he would be inclined to recommend sinking for coal a considerable distance north of Asch, were it not for the probably-enormous thickness of overlying barren strata in that district. Two hypotheses are deducible from the known facts, namely:—(1) The Campine basin belongs to the same fold-series as that in which the Staffordshire coal-field lies; or (2) it belongs to the fold-series of the Yorkshire coal-field. Whichever of these hypotheses is the true one, further search for coal in a west-north-westerly direction is the proper course to follow, the thickness of the overlying barren strata at Antwerp and thence seaward being estimated at 1,150 feet or less.

The second author points out that the new coal-field is the Belgian parallel of the Essen basin of Westphalia, and believes that a similar parallel to the Bochum basin will be struck somewhere north-west of Visé.

With regard to the thickness of barren strata and quicksands through which it might be necessary to sink before reaching the coal, he admits that for technical reasons the Kind-Chaudron process is not applicable at depths exceeding 1,300 feet; but the Tomson process has been recently introduced in Westphalia with great success, and at Dorsten on the Lippe (for instance) about 2,300 feet of water-bearing barren strata have been sunk through without hindrance.

The third author deals in detail with the probabilities as to the thickness and character of the barren strata which conceal the Campine coal-field. The old Palæozoic surface appears to rise westward, whence it may be inferred that the farther one proceeds in that direction the less deep will it be needful to sink before reaching the coal. Borings are especially recommended in the district north of Antwerp and round about Knocke. Probably about 560 feet or so of comparatively dry Cretaceous rocks overlie the Coal-measures; and the Cretaceous in its turn is overlain by an average thickness (in the Campine district) of 1,150 feet of Tertiary and Quaternary deposits, among which are certainly some quicksands.

The fourth author examines the probability that much of the new coal-field underlies State domains, such as the military camp of Beverloo (the Belgian Aldershot). Meanwhile borings are being put down everywhere in the Campine district with such feverish haste that careful records of the strata passed through are out of the question, as far as these borings are concerned. The author considers that the State itself should undertake

a search for coal in its Campine domains, and should more particularly seek to determine the southern boundary of the coal-field. That the Belgian Government will not improbably include coal-mining among its multifarious functions, ere long, is illustrated by the Bill laid before the Senate to reserve as State mining-properties the lands adjacent to the camps of Beverloo and Brasschaet. L. L. B.

THE PYRITES-DEPOSITS OF VEZIN, BELGIUM.

Description des Gîtes métallifères de la Belgique: I.—Mine de Pyrite de Vezin. By X. STAINIER. *Bulletin de la Société Belge de Géologie, de Paléontologie et d'Hydrologie*, 1902, *vol. xvi., Mémoires, pages* 1-15, *with* 7 *figures in the text and* 1 *plate.*

This memoir, the first instalment of a series dealing with the metalliferous deposits of Belgium, is devoted to an exhaustive study of the Vezin pyrites-deposits, situated on the northern rim of the Namur basin. For the first half of the nineteenth century oolitic hæmatite had been successfully worked in the Vezin district by several companies, and the pyrites was accidentally discovered in 1860-1862 in the course of exploration-work carried out in extension of some old mines. These had been discontinued, by reason of a disturbance in the strata, which is a factor of considerable importance in the tectonics of the district. It is conditioned by the Vezin fault, which appears to branch off from the great Landenne fault: the latter brings the Carboniferous dolomites down against the Silurian rocks. The mass of rocks between the two faults underwent at some remote period tangential pressures, crumpling up and upheaving the sedimentary deposits (Oolitic hæmatite among them), and into the fissure thus caused metalliferous solutions welling up from below brought what the author terms an undoubted vein-deposit of pyrites. The fissure was further filled with substances broken from or leached out of its walls, and with its northerly dip is brought up abruptly against the Vezin fault which is inclined southward. The argillaceous infilling of that fault probably prevented the further upward travel of the metalliferous solutions towards the surface. On the other hand, where these solutions met the hæmatite they percolated through it, following the general slope of the deposit, and altered it into pyrites. The author concludes that the Vezin ore-body is both sedimentary and metamorphic, and remarks that this is by no means an exceptional occurrence in the district.

Workings were carried on, on a small scale, in the years 1866-1868, but one does not gather from the author's observations that the metal-mining industry is now active there, or likely to be so again. L. L. B.

THE COAL-FIELDS OF THE PLATEAU CENTRAL, FRANCE.

Sur les Bassins houillers du Plateau Central. By A. DE GROSSOUVRE. *Compte-rendu de l'Association Française pour l'Avancement des Sciences*, 1902, *pages* 212-213.

On looking at the geological map of the Central Plateau of France, one notices at the first glance the long, nearly rectilinear, belt of coal-bearing beds extending from Moulins in the north to beyond Champagnac in the south, and continued thence by a series of small patches as far as St. Mamet.

No doubt the Decize coal-basin on the north is also associated with this belt. West of this Mr. Mouret has traced a similar belt, indicated by the "coal-fields" of St. Chamans (Argentat), l'Hôpital, Bougogles, Mazuras (south of) and Bosmoreau (north of) Bourganeuf. These two belts were at one time regarded as long, narrow channels, filled up by the deposits of the Stephanian age, but recent researches go to prove that they are nothing of the kind. Nor do they represent a crushed syncline: most of them, indeed, are mere fragments which have been preserved by sagging from erosion. The faults by which they are bounded are generally reversed faults, and the author concludes that the sagging was due to lateral pressure, the sunken masses being wedge-shaped, with the thin end of the wedge directed upwards.

The faults of Argentat and Mauriac are of much earlier date than the Stephanian age, and faulting must have there been repeated along the same lines after the deposition of the Coal-measures. L. L. B.

THE LOIRE COAL-FIELD, CENTRAL FRANCE.

Du Bassin de la Loire; sur les Tiges debout et Souches enracinées, les Forêts et Sous-sols de Végétation fossiles, et sur le Mode et le Mécanisme de Formation des Couches de Houille de ce Bassin. By C. GRAND'EURY. *Comptes-rendus du huitième Congrès géologique international*, 1900 [1901], *pages* 521-538.

The author first of all remarks that the Loire coal-field is the most extensive [in depth] and the richest of those of Central France. He gives the following conspectus of the strata in ascending order:—

Series.	Thickness.	Number of Workable Coal seams.	Total Thickness of Coal.
	Feet.		Feet.
Basement-breccias...	1,312	—	—
Coal-bearing group of Rive de Gier	328	3	33
Intermediate barren-grits and conglomerates...	2,624	—	—
Productive series of St. Etienne	2,952	15	98
Avaize group, including the Rochettes seam ...	1,312	13	33
Upper micaceous conglomerates	1,640	—	—
Rothliegendes (?)	1,312	—	—
Totals ...	11,480	31	164

The lower groups occupy only part of the surface of the coal-field, and the upper cover a comparatively small extent—nowhere is the whole succession to be seen in one section. The author wishes to prove that the coal was formed *in situ*, basing this conclusion on the very numerous examples of rooted trees and of vegetable subsoils (under-clays) found in these Coal-measures. He proceeds to describe in detail the positions in which *Stigmaria, Syringodendron, Calamites, Calamodendron, Psaronius*, etc., occur therein, and draws attention to the variation in habit of the roots according to the nature of the soil in which they grew. On the whole, he describes the life-conditions of the Carboniferous flora as analogous to those of the vegetation of the Great Dismal Swamp in the United States. In the St. Etienne district, the under-clay is found not only at the floor of

the seams but also within the seams themselves, being in such cases very carbonaceous.

He then discusses the relation between the rooted trees and the coal-seams, and points out that at St. Chamond, for instance, the connexion is clear between the roots of *Cordaites* and the overlying coal formed out of the stalks, stems and leaves of the same plant.

At the same time he admits that, speaking generally, coal is mainly drifted vegetable matter. Yet all coal resembles more or less that which has been plainly formed *in situ*—the drifted débris are similar in character to the stems, etc., of the rooted fossil trees. He infers then that the constituent elements of coal were derived from marshy forests which were continuous with those actually occupying the basin of deposition, but extra-lacustrine, permanent, while on their floor humus was formed much as in peat-mosses. On the other hand, the conditions of the basin of deposition were those of a swamp-bottom at the present day; the remains of (fossil) plants which fell into the water at the edge of the swamp ultimately formed stratified deposits, and thus it is that certain coal-seams are in part derived from vegetation *in situ*, in part from drifted matter, much as the subaquatic peat of certain marshes of our own time. The comparative infrequency of coal formed *in situ* alone may be explained by the fact that the very position of the permanent forest-swamps prevented them from being buried soon enough by a protective covering of mineral sediments, and so they were in most cases swept away. We have only now remaining, from the peaty marshes of different geological periods, the strata which lay at the bottom, and were sealed up from destruction by the accumulation of silt, etc.

Returning to the conditions of formation of the Loire coal-field, it appears evident that the strata in which the fossil trees were rooted were in very shallow water. The repetition of root-bearing clays at intervals of 160 to 330 feet at Le Treuil, Montrambert, etc., shows that there were periods of slow sagging. When there is a great mass of strata, intercalated between the root-bearing clays, as at Beaubrun, La Grand'Combe, we may infer that subsidences were sudden and extensive. But the presence of a coal-seam of any considerable thickness implies a comparatively stable condition of the soil. The barren strata were, in the author's opinion, deposited in periods which followed on orogenic earth-movements of far-reaching effect. There is a striking contrast between the felspathic rocks of the Rive-de-Gier series and the quartz-mica conglomerates which form the base of the St. Etienne group, and this general substitution can only be accounted for by such orogenic movements. Near its northern boundary, the Coal-measure belt has been highly metamorphosed by silicco-felspathic springs—those at St. Priest have formed regular bands of chalcedony within the Coal-measures. The author also adduces other evidence of the part played by eruptive magmas and thermal waters in the geological history of the coal-field.

He then enquires into the applicability of the delta-theory to the Loire basin, and finds that the Coal-measures were in part deposited by a stream which flowed in from the north or north-west, and in part by more rapid streams coming in from the south. A careful examination shows that the deposits dovetail into each other like wedges, while the coal-seams are fairly parallel. L. L. B.

THE PISOLITIC IRON-ORES OF BRIEY, LORRAINE, FRANCE.

(1) *Des Gisements de Minerais de Fer oolithiques de l'Arrondissement de Briey (Meurthe-et-Moselle) et de leur Mode de Formation.* By GEORGES ROLLAND. *Comptes-rendus du huitième Congrès géologique international*, 1900 [1901], *pages* 664-672, *with plates X-XI. (maps).*

This memoir is complementary to the papers already published by the author in the *Comptes-rendus* of the Paris Academy of Sciences. In 1898, he drew attention to the discovery that the pisolitic ore-belt long worked in the former department of the Moselle extends beneath the district of Briey into the department of the Meuse. This discovery was the outcome of two series of borings (161 in all), put down during the years 1882 to 1886 and 1892 to 1900.

Taking into account the present state of the arts of mining and metallurgy, the new area of workable ore may be estimated at 98,840 acres, nearly the whole of which has been already parcelled out into mining concessions On maps, which gave the depths from place to place of the floor of the grey ore-bed, the author plotted out approximately the curves of equal thickness and equal richness and equal tenour (in iron); the maps so constructed show that neither the thickness nor the distribution of the ore bears any general, regular relationship to the subterranean topography or to the position of the faults.

The variations in thickness show that during the deposition of the ores little synclinal basins were formed at the points where the slope of the great basin was steepest, and the order of superposition of the strata indicates that the Jurassic topography differed entirely from the present topography. The author's general conclusion is that the pisolites are a sedimentary formation of continental origin.

The maps which accompany the paper give a clearer picture of the new iron-ore field and its characteristics than could be built up from many pages of description. L L. B.

(2) *Le Gisement de Minerai de Fer oolithique de la Lorraine.* By FRANÇOIS VILLAIN. *Annales des Mines*, 1902, *series* 10, *vol. i., pages* 113-220 *and* 223-322, *with* 6 *figures in the text*, 2 *vertical sections and* 8 *plates.*

The nine chapters of this elaborate memoir and its wealth of illustrations form a perfect cyclopædia of all that is at present known regarding the pisolites of French and German Lorraine, and the bordering districts of Luxemburg. It is true that the author leaves out of count the Nancy basin, as being familiar and as having failed to give rise to any interesting discoveries of late years; whereas the Briey basin, to which he devotes considerable attention, has only been thoroughly investigated as recently as 1894-1899.

The annual production of the entire region reached in 1900 the total of 18,000,000 tons of ore. The workable area is estimated at about 260,000 acres, and the amount of available ore at 5,000,000,000 tons. The age of the rocks in which these pisolites occur is undoubtedly Oolitic: the strata at the surface belong to the Bathonian division of that system, but the ores have to be reached by means of shafts in many cases 600 and 800 feet deep. No less than seven French companies have put down or are putting down such shafts, although in former days the State used to work the ores by means of adits driven in the hillsides, or even opencast. Such indeed are the methods of working still carried on in Luxemburg, which

duchy produces a third of the total annual output. In German Lorraine many of the mines have to be drained by powerful pumping-engines.

Details are given of various borings, showing several seams of pisolite intercalated among limestones and marls. When completely developed the ore-formation ranges between 80 and 160 feet in thickness, but it thins out gradually to nothing towards the edges of the basins. In the Nancy district, the thickness never exceeds 33 feet. The good average quality of ore contains about 42 per cent. of metallic iron and 2 per cent. of phosphoric acid: some extraordinarily good samples contain as much as 60 per cent. of metallic iron.

In his preamble to an exhaustive review of the literature of the subject, the author points out that all writers have invariably laid great stress on the faults which cut through these Lorraine deposits, while at the same time explicitly or implicitly asserting that the aforesaid faults played no part in the distribution of the ores. The author, however, holds a diametrically opposite opinion, as to some of the faults at any rate, which he terms *failles nourricières* ("feed"—or "supply-faults," if we view the ore in the light of material that is "fed" or "supplied" to a particular locality). He appeals to the late Mr. Godwin-Austen's theory, more recently expanded and illustrated by Prof. Marcel Bertrand, of the superposition and repetition through successive geological ages of synclinal and anticlinal folds in a given region, and a similar repetition of fractures along the same lines. The rich ore-deposits, in the present instance, occur in the synclines, and are literally basins.

The hypothesis of "supply-faults" is enunciated as follows:—

(1) The iron-ore was brought to the sea-bottom by fissures in the earth's crust through which thermal springs welled up, carrying the iron chiefly in the form of carbonate. This carbonate was subsequently decomposed by the sea-water, and threw down a pulverulent precipitate of oxides which enriched the contemporaneous sediments.

(2) When the deposit was abundant, a bed of ore was formed not only in the neighbourhood of the thermal springs, but extended over an area which was dependent on the strength of the currents and the topography of the sea-bed, as well as on the amount of ferruginous material.

(3) It is inferred that the most abundant emissions of ore took place precisely through those fault-fissures which are still conspicuous by their downthrow, in comparison with the other faults. It is not asserted that the present surface-relief of the deposits is actually identical with that of the Toarcian sea-bed, but that it is very similar to it.

(4) The cessation of the ferruginous thermal springs marks the close of the Toarcian era of dislocation and the beginning of the Bajocian—an era of tranquil deposition, as shown by the fairly uniform thickness (often more than 100 feet) of the micaceous marls which mantle over the entire ferruginous formation.

The third chapter is taken up with the description of the Longwy basin, the fourth with that of the Landres basin, the fifth with that of the Ottange-Tucquegnieux basin, and the sixth with that of the Orne basin. In the seventh chapter, the author deals with the origin of the silica and alumina contained in the ores and with that of the carbonates. In the eighth chapter he shows that the phosphorus associated with these ores is not, as was long believed, of organic origin; and in the ninth chapter he emphasizes and re-asserts his hypothesis of "supply-faults," which themselves originated in eruptive phenomena. L. L. B.

MINERALS OF CENTRAL FRANCE.

Excursion à quelques Gîtes minéraux et métallifères du Plateau central. By L. DE LAUNAY. *Comptes-rendus du huitième Congrès géologique international*, 1900 [1901], *pages* 938-970, *with* 11 *figures in the text.*

Pisolitic Iron-ores of Berry.—These ores occur scattered about in pockets over a radius of about 25 miles around Bourges. They are worked by shallow pits which are necessarily sunk in a rather haphazard way, as it is not always certain where or whether the ore will be met with, and the workings are being constantly shifted from one locality to another. The total output for 1900 is estimated at about 30,000 tons, and the number of workpeople employed at the seven or eight mines now in operation is 50 or so.

These ores are in no way connected with those of Mennetoux, of Neocomian age, in the north of the department of the Cher, of which Bourges is the chief town. At Mennetoux, mining has been re-started quite recently and the industry has developed enormously from 1899 onwards. In that year the output was 30,000 tons.

The average percentage composition of the pisolitic ores is as follows:—Peroxide of iron, 58·70; lime, 1·20; alumina, 12·10; silica, 10·60; phosphorus, 0·20; sulphur, traces; manganese, not estimated. But other analyses show that the percentage of alumina in some cases is as high as 23, and that of silica 11·5 (ores of St. Florent).

The so-called "siderolithic" formation, to which the ore-pockets belong, extends over a vast stretch of country, and is in part overlain by lacustrine limestones correlated with the Oligocene limestone of Brie. The formation has all the characteristics of a shallow-water deposit, laid down at a time (when sedimentation was not very active) following upon a long period of upheaval. The pisolites are associated with mottled clays, which in places contain dark-yellow or red rounded alumino-ferruginous nodules, and there is an almost insensible gradation from these into the pisolites. The last-named are especially abundant at the base of the clay. The pockets occupy hollows eroded out of the Jurassic limestone, which itself shows signs of intense alteration around these hollows. The author does not believe that the hollows were formed by any deep-seated phenomena of dislocation. On the other hand, he holds that the siderolithic clays are not mere decalcification-products of the limestone due to pluvial action, but that they must have been formed in pools or lake-basins, wherein a good deal of carbonic acid (derived perhaps from thermal springs) was in solution. The presence of this acid would be a potent factor in eroding hollows out of the limestone-bed of the lake.

Amblygonite-mine of Montebras (Creuse).—This mine, formerly worked for tin, is now the sole existing source of amblygonite, a mineral utilized for the production of lithia, of which it contains from 6 to 8 per cent. The author remarks, by the way, that the lithia-industry is practically the monopoly of Bonn-on-the-Rhine: besides amblygonite, lithia-bearing micas are there used up, imported from Moravia, from Chédeville near Limoges, and from Zinnwald in Saxony. The mineral output of Montebras is about 100 tons *per annum*. For some time the amblygonite was got by simply overhauling the waste-heaps of the old tin-mine, and only recently have workings been begun below bank. Even so, they have not as yet gone below the superficial kaolinized belt, where the rocks are altered by all sorts of secondary action, or have been disturbed by the ancient tin-workings. The country-rock would appear to be a porphyroidal granulite with primary

quartz: this is seamed by veins in which amblygonite is associated with quartz and tinstone. Moreover, the entire mass of the granulite is more or less stanniferous. The principal "vein" is some 40 feet long, with a maximum breadth of 13 feet.

Antimony-mine of Montignat (Allier).—This mine is more interesting, as being a sample of the many antimonite-deposits scattered about the Central Plateau of France, than important industrially. It has been worked and then abandoned again several times over, since it was first started in 1783. The ore occurs in a stockwork of quartz, in a dyke of granulite which cuts through a granite-gneiss on the right bank of the Cher, 1¼ miles above Chambouchard. The granulite strikes 40 degrees north, and dips steeply eastward. The antimonite-veinlets are extremely irregular, and their thickness varies from ¼ to 1 inch. Sometimes mispickel is associated with them very rarely the antimony-ore is found to swell out into lenticles several inches thick. The age of the deposit is intermediary between the Dinantian and the Stephanian (stages of the Carboniferous system). The author proposes shortly to publish a detailed monograph on the antimony-ores of the Central Plateau.

Kaolin-mine of Les Collettes (Allier).—These mines are worked in the decomposition-belt of a white-mica granite or granulite, which forms an isolated mass amid the mica-schists. The workings have proved the limit in depth of the kaolinized belt, and therefore disprove definitely Prof. Daubrée's theory that kaolinization is an ancient phenomenon due to the action of stanniferous fluorides. It is evidently connected, on the other hand, with the recent action of surface-waters. Three main reefs of quartz stand out in the opencast workings, and where they are intersected by cross-veins, kaolinization has been most active (owing to the more rapid circulation of percolating waters), reminding one of the enrichment of metalliferous veins at intersections. The classic kaolin of St. Yrieix, near Limoges, is purer than that of Les Collettes, because it is the decomposition-product of a pegmatite, instead of being that of a granulite.

St. Eloy Colliery.—This mine is on the strike of a long rectilinear belt of Coal-measures which cuts diagonally across the Central Plateau. This is not simply a chain of ancient lakes, or the mere infilling of some ancient basin: it is generally transverse to the ancient folds, and appears to have resulted from a great dislocation which took place at some time between the Dinantian and Stephanian epochs. The Coal-measures underwent, moreover, intense transverse compression extending over a long period, with the result shown in the author's sections, where the contortions, the overfolds, and the irregular thickening and thinning of the coal-seams are extreme. The strata are mainly shales and grits, conglomerates being poorly represented when such do occur, they are mainly made up of gneiss-pebbles. The coal is mostly semi-lignitous, burns with a long flame, and is good for household purposes: the upper and middle seams alone are worked, the lowermost seam being still unworked.

On the north the coal-belt narrows suddenly and all but disappears between St. Eloy and La Peyrouse, but its course can generally be followed by tracing a blackish clay: at Montmarault the Coal-measures re-appear with a breadth of 330 to 500 feet, and broaden out more and more until abreast of Noyant they reach their maximum width in this region, that is, more than 2 miles.

Phenomena of contact-alteration of coal are noticed at St. Eloy. There

is a rock termed "white bind" or *gore* (which plays a part similar to that peculiar to the porphyrites of Commentry) particularly in connection with the top coal-seam. At the contact, the coal is hardened, graphitized, and contains small veinules of crystallized baryte (no doubt derived from the orthoclase-felspars of the "white bind").

Asphalt-mines of Pont du Château (Puy de Dôme).—Over an area measuring about 100 square miles, between Clermont-Ferrand, Riom, and the river Allier, bitumen and asphalt-deposits are numerous amid the Tertiary beds associated with the younger basalts. North of the area of basaltic eruption, the Tertiary strata contain no bitumen, but south of it bitumen is found in the *Helix-Ramondi*-limestones (Aquitanian) of Pont du Château and Les Roys, in the Upper Tongrian marls of Puy de la Bourrière, in the sands and arkoses of Lussat and L'Escourchade, etc.

The asphalt in the Pont-du-Château mines occurs as a distinctly localized impregnation in a bed of concretionary *Helix-Ramondi*-limestone (from 13 to 20 feet thick) overlain by grey marly limestone, and underlain by other marly limestones. The impregnation is manifestly of later date than the deposition of the limestone in which it occurs, and its concentration there is probably due to the argillaceous character of the overlying and underlying beds. The asphalt appears to have come from below, as indicated by the presence of small veins of it in the floor of the limestone-bed. A sample of the asphalt, analysed at the Paris School of Mines, was found to contain 2·69 per cent. of sulphur.

The Manganese-mines of Romanèche (Saône et Loire).—These mines show an annual output of 11,000 tons. The ore contains neither phosphorus nor sulphur, and hardly a trace of arsenic; it is chiefly used for metallurgical purposes, but some of the richer ore (containing 55 per cent. of manganese) is sold in the form of powder to glass-factories. The deposits were discovered in 1750, and worked for the first time in 1823. At present, two kinds of ore-bodies are being worked:—(1) A primary vein-deposit in granite, and (2) a mass which occurs amid the sedimentary strata of Trias, Rhætic, and Toarcian age that abut on the granite, and is manifestly of secondary origin.

One peculiarity of the psilomelane of Romanèche is the constant association of baryte with the ore. Among other associates are fluor-minerals and silica. Calcite is entirely absent from the vein-deposits, but occurs in the secondary deposits. Another peculiar feature is the gradual replacement of the manganese by iron, at depths varying between 260 and 330 feet. At 260 feet, the ores only contain 8 per cent. of manganese. Down to this depth, the greatest so far worked in the mine, the granite country-rock is completely decomposed, and the *Gryphæa*-limestone in which some of the secondary deposits occur crumbles to dust. The abundant mine-waters are highly charged with sodium and magnesium chlorides.

For further details regarding most of the deposits described in this memoir, the author refers the reader to his *Traité des Gîtes minéraux et métallifères* and the bibliographical list which accompanies it.

L. L. B.

THE KAOLIN OF ST. YRIEIX, FRANCE.

Observations sur les Kaolins de Saint-Yrieix. By L. DE LAUNAY. *Annales des Mines*, 1903, *series* 10, *vol. iii., pages* 105-115, *and* 5 *figures in the text.*

The author does not agree with those who attribute to kaolin a deep-seated origin, but regards it as a product of surface-decomposition. He claims the deposits herein described as so much additional evidence in support of his views.

The kaolin-quarries of St. Yrieix occupy a belt some 12 miles in length to the east of that town, ranging towards Coussac-Bonneval and Mongibaud along a fairly level plateau, at an average height of 1,200 feet above the sea. These quarries have been renowned since 1765 for the superior quality of the kaolin which is got from them; but they are being gradually worked out, and the annual production is now much reduced. The increased cost of working, the exhaustion of the deposits in depth (they are rarely worked more than 130 feet below the surface), and the competition of Cornish kaolin, are all factors which have conduced to this diminution.

The mineral is derived from the decomposition of pegmatites properly so-called, and also from exclusively felspathic-rocks such as are sometimes associated with granulites: these occur as veins seaming the crystalline schists. Some of the kaolin-"veins" occur in the midst of amphibolites (hornblende-rocks), the blackness of the latter showing up the brilliant whiteness of the former: such is the case at Marcognat, of which quarry the author figures a section taken in 1902. The purity of the mineral is due to the fact that, in the undecomposed vein, felspar occurred alone or associated only with quartz, but in any case quite free from mica.

L. L. B.

BROWN COALS IN THE PROVINCE OF POSEN, PRUSSIA.

Beitrag zur Kenntnis der Braunkohlenablagerung in der Provinz Posen. By — KRUG. *Zeitschrift für praktische Geologie*, 1902, *vol. x., pages* 53-55, *with* 1 *figure in the text.*

The brown coals which have been worked of recent years near Stopka, about 10 miles north of Bromberg, are of considerable importance for Eastern Prussia, as they have given rise to a flourishing mining industry. The age of the seams remains as yet undetermined: they are underlain by white micaceous quartz-sands, and overlain by blue and grey clays (sometimes mottled with red and yellow bands). The last-named constitute the so-called "Posen fire-clay," which Dr. Berendt considers to be of Miocene age. If his assumption were correct, the brown coals would then probably be Uppermost Oligocene or Lowermost Miocene. Under about 60 feet of clay come five coal-seams, the higher of which vary in thickness from 4 inches to 3 feet or more, while the lowest is 10 feet thick. They occur in a saddle (anticline and syncline) which extends for more than a mile and a quarter from north-west to south-east. The crest of the anticline rises to within 65 feet of the surface, but the crest is itself undulating, forming thus several small basins. Borings have shown that the seams on the northern limb dip much more regularly than on the southern: further investigation shows the seams on the south to be completely turned over, and to be so "smashed up" that the coal is ground to dust.

The above-described Tertiary strata are overlain by the Glacial Drift (sands, gravels, and boulder-clays), and the Drift is, of course, thicker

(150 feet) where the Tertiary is least disturbed and the coal-seams are practically horizontal. A small but persistent seam of lignite, about 1 inch thick, occurs in the Drift.

It seems possible that the abrupt folding of the Tertiary strata is assignable to the "thrust" or "push" exerted by the advancing ice-cap during the Glacial Period. L. L. B.

THE MAIN EASTERN FAULTS IN THE AIX-LA-CHAPELLE COAL-FIELD, GERMANY.

Die östlichen Hauptstörungen im Aachener Becken mit besonderer Berücksichtigung ihres Alters. By — JACOB. *Zeitschrift für praktische Geologie*, 1902, *vol. x., pages* 321-337 *and* 1 *plate.*

The three great faults described in this paper strike practically across the strata, from south-south-east to north-north-west, with a general north-easterly hade. They are known as the Münstergewand, the Feldbiss, and the Sandgewand. Between the two last-named another great fault-line, known as the western main fault, has been recently discovered in the Nordstern colliery.

The evidence furnished by 63 bore-holes, full details of which are appended to the paper, as to the varying character and thickness of the Tertiary cover, leads the author to the following conclusions. The strata continued to sag along these fault-lines even after the deposition of the Miocene beds, but on the other hand faulting must have started long before then. The downthrow within the Tertiaries is less than that proved within the Coal-measures: for instance, a difference of level in the latter of 1,050 feet, becomes only 426 feet in the Upper Oligocene marine sand-stones. This is explained on the hypothesis that sagging took place repeatedly along these fault-lines, to some extent long before the deposition of the Tertiaries, and to some extent after the deposition of the Miocene.

The circumstance that the Coal-measures formed an even surface at the time when the Tertiary rocks began to be laid down in the Aix-la-Chapelle region does not invalidate these conclusions. The denudation extending over the long time-interval between the Upper Carboniferous and the Upper Oligocene was sufficient to pare down such inequalities of level as may have arisen through the sinking of different "fault-blocks." L. L. B.

THE SEARCH FOR COAL IN SAXONY.

Wo könnte in Sachsen noch auf Steinkohle gebohrt werden? By K. DALMER. *Zeitschrift für praktische Geologie*, 1902, *vol. x., pages* 223-225; *and* 1903, *vol. xi., pages* 121-123.

The author considers that within the next 30 or 40 years many of the Saxon collieries must needs be shut down, owing to the exhaustion of the deposits. Compensation for this diminution in coal-output can only be sought by opening up fresh coal-fields, and the question then immediately arises as to what localities are likely to afford some prospect of successful boring-operations.

The boring put down by the Prussian Government in the years 1880-1886, at Schladebach, near Merseburg, struck the Upper Coal-measures at a depth of 2,102 feet, and passing through a thickness of these measures of no

less than 3,247 feet (all comparatively barren) was stopped in Upper Devonian shales. Another boring, which did not go down to quite so great a depth, at Dürrenberg, showed a vast thickness of Upper Carboniferous rocks there also, but again without any coal-seams. Various stratigraphical reasons are adduced to show that the Coal-measures really extend much farther than is generally suspected in the eastern part of the province of Saxony and thence into the Leipzig district within the kingdom of Saxony itself, until their further extension is barred by the concealed Archæan ridge which stretches from Leipzig to Riesa. No borings have as yet been carried far enough down in the district north of Leipzig to prove the Coal-measures, but the experiment seems worth trying, and the author recommends also that boring-operations should be started in the northern part of the Permian basin of Central Saxony, and especially between Borna and Lucka. One could hardly hope for definite results without going down to a depth of about 2,000 feet.

With regard to the Erzgebirge basin, an extension of the known coal-fields can only be looked for in its southern part, and the author holds that the best locality for a trial-boring would be somewhere to the south of Werdau. Here again, it would be necessary to go down to a depth of at least 2,000 feet. Another good locality, for which reasons are adduced would appear to be Coselitz, between Riesa and Elsterwerda.

L. L. B.

MARINE FOSSILS IN THE COAL-MEASURES OF UPPER SILESIA, PRUSSIA.

Neuer Fundpunkt von mariner Fauna im Oberschlesischen Steinkohlengebirge. By R. MICHAEL. *Zeitschrift der Deutschen geologischen Gesellschaft*, 1902, *col. ltr., Protokolle, pages* 63-66.

The uppermost group of the Carboniferous in the province of Upper Silesia contains exclusively brackish-water or freshwater forms of life. So too does the Middle or so-called "Saddle" group, important in Upper Silesia for the number, thickness, and quality of its coal-seams. In the Lower or Border group (correlated with the Ostrau series) marine organisms come in. They have been found at many different horizons in all the deep borings in the western portion of the field. The marine fauna too has been proved immediately below the [bottom] seams of the Middle group in the main "saddle" which strikes eastward from Zabrze, across Morgenroth, Königshütte, and Myslowitz into Russian territory.

In this paper, the author describes the occurrence at Radzionkau, of three marine faunas at as many different horizons, brackish-water organisms (such as *Anthracosia*) occurring at an horizon between the two lowermost marine faunas. Various species of *Productus*, *Lingula*, *Aviculopecten*, *Nucula*, *Leda*, *Orthoceras*, *Bellerophon*, *Pleurotomaria*, and one trilobite (*Phillipsia*) were obtained, besides undeterminable fragments of goniatites.

L. L. B.

THE PERMIAN AND TRIAS OF THE RUHR COAL-FIELD.

Zur Kenntnis der Dyas- und Triasablagerungen im Ruhrkohlenrevier. By GOTTFRIED MÜLLER. *Zeitschrift für praktische Geologie*, 1901, *col. ltr., pages* 385-387.

The cores of a boring at Kirchgell Heath, south-west of Dorsten examined by the author, showed 16 feet of porous dolomite with undoubted

Permian fossils, at a depth of 1,404 feet from the surface. At the Gladbeck colliery, the cavities in similar dolomite are in part encrusted with copper-ores, and the dolomite is underlain by 3 feet or more of thinly-bedded anhydrite and gypsum. In the Springfield (Kirchgell) boring, the basement of the Permian is formed by a conglomerate about 20 inches thick, and below this comes 30 feet of red-stained shales and clays, followed by the uppermost coal-seams.

In the Vreden boring, near Ahaus, rock-salt is proved between the depths of 1,285 and 1,370 feet. It may be inferred to be of Keuper age, and below it comes some 1,600 feet of Bunter Sandstone.

At the Preussen II. pit, below 1,170 feet of Cretaceous and Neocomian beds the Red Rocks are struck: the uppermost of these are shown by the plant-remains to be of undoubted Rothliegendes age. Lower down occur shales with striations which the author believes to be "palæoglacial." He adduces the evidence which tells against their being slickensides or thrust-phenomena. These shales are below the basement-conglomerates of the Rothliegende, and it is pointed out that an enormous period of time must have elapsed between the first deposition of that formation and the last deposition of the highest seams of the underlying Gas-coal group.

L. L. B.

THE NEWER STRATA OVERLYING THE RUHR COAL-FIELD, GERMANY, AND THE WATERS WHICH THEY CONTAIN.

Ueber die Deckgebirgsschichten des Ruhrkohlenbeckens und deren Wasserführung. *By* DR. A. MIDDELSCHULTE. *Zeitschrift für das Berg-, Hütten- und Salinenwesen im Preussischen Staate*, 1902, *vol. l., Abhandlungen, pages* 320-345.

In the east of the Ruhr coal-field, the Carboniferous strata are immediately overlain by the Upper Cretaceous, but in the west the Zechstein (Permian) and Triassic Bunter Sandstone Series intervene between the Chalk and the Coal-measures. At Gladbeck, the last-named are reached at a depth of 1,460 feet from the surface, 416 feet of which represent the thickness of the Bunter and about 27 feet that of the Zechstein. The Coal-measures are directly overlain by a 2 feet band of dark-grey micaceous bituminous shale, containing plant-remains. The Zechstein Limestone on the top of this is very sharply marked off from it. The shale is regarded as the equivalent of the Kupferschiefer, and its presence has been proved in many other sinkings, but nowhere in the Ruhr basin does it contain metalliferous ore. The thinly-bedded, tough, light-grey Zechstein Limestone is overlain by enormously thick, nearly pure white conglomerates (50 or 60 feet) of Bunter age: their constituent pebbles deserve rather the term "boulders," as some of them are so large, that they have to be blasted away before a sinking can be carried down to the coal. The rest of the Bunter consists of micaceous, dark-red, fine-grained sandstones with intercalated bands of clay. The Bunter series is generally found to increase in thickness as borings are carried northward: on the other hand, where the Upper Zechstein contains rock-salt, it in turn swells out to a thickness of hundreds of feet, as shown by sinkings near Wesel. At Schermbeck station, the Coal-measures are only reached at a depth of 2,920 feet from the surface.

The evidence obtained from the numerous borings put down throughout the region of the Lower Rhine leads the author to conclude that the

Bunter and Zechstein of that district are of the same age as, and practically continuous with, the Trias and Permian which form the north-eastern and eastern margins of the Cretaceous basin of Münster.

These Upper Cretaceous beds, as before mentioned, overlie unconformably and overlap the Bunter Sandstone, and then the Coal-measures. The lowest portion of the series in the Ruhr district consists of the Cenomanian or Tourtia glauconitic sands, with thick layers of clay-ironstone, and tough glauconitic marls. These are followed in upward succession by the Turonian light-grey or white hard marls, and these by the softer, more sandy Emscher Marls. In the neighbourhood of Recklingshausen the last-named are overlain by sandy marls of Senonian age.

It is noticeable that, as one proceeds eastward from the western margin of the basin, a gradual change in the lithological character of the Cretaceous deposits becomes manifest. While sandy beds predominate in the west, calcareous and argillaceous beds gradually assert their supremacy towards the east—in which direction the deeper sea must have lain.

In the east of the Ruhr basin, Glacial Drift immediately overlies the Cretaceous, but in the west, near the Rhine, Tertiary deposits intervene, attaining a thickness in the neighbourhood of Wesel of something like 1,000 feet. Going from south to north, the Coal-measures are found to lie deeper and deeper below the surface, and this change of level is very regular in the eastern portion of the basin; but in the western portion there is no such regularity, the drops in level being sudden and considerable. At all events, one point appears certain, that the farther northward borings are put down the deeper will the Coal-measures be found to lie.

With regard to water, the Bunter series is, of course, a great natural reservoir, and has been in that way a fruitful source of trouble in sinking. Some of this water, analysed at Bochum, yielded a considerable proportion of common salt, and small amounts of magnesium-salts. Brine-springs occur in nearly all the underground workings of the pits south and south-west of Gladbeck, and undoubtedly come from the Triassic and Permian rocks, finding their way downward through the fault-fissures of the Coal-measures. Miners in the Ruhr coal-field will always have to reckon with the possibility of sudden and voluminous outbursts of water into the workings.

With regard to water in the Cretaceous rocks, the lowermost beds—the glauconitic Tourtia-waterbearing sands, act as a protective belt to the Coal-measures against further inflows of water from overlying beds. But where eastward the above-mentioned lithological change, from general "sandyness" to general "marlyness" takes place, water-bearing fissures make their appearance, so that the deep-level shafts of the Ruhr basin in sinking through the Cretaceous have had to contend with more or less voluminous inflows of water, being in some cases completely drowned. In the Cretaceous area of Münster numerous brine-springs well out from the hard, perpendicularly fissured Turonian marls. The neighbourhood of Hamm-an-der-Lippe is especially rich in such springs. The author describes some of these, and gives chemical analyses.

The Emscher Marls contain no brine-springs, and in fact form a water-tight compartment between the overlying Senonian and the underlying Turonian divisions of the Cretaceous, which are both waterlogged.

L. L. B.

IRON AND MANGANESE-ORES OF NIEDERTIEFENBACH, GERMANY.

Über die Entstehung der Mangan- und Eisenerzvorkommen bei Niedertiefenbach im Lahntal. *By* J. BELLINGER. *Zeitschrift für praktische Geologie*, 1903, *vol. xi., pages* 237-241, *with* 5 *figures in the text.*

These deposits occur in rocks of Devonian age, between the *Stringocephalus*-limestone and the younger Schalstein (tuff). In form the ores vary from mere dendritic markings to huge shapeless nodules, and in composition from pure oxides of iron and manganese to excessively aluminated and silicated compounds. They may be regarded as the outcome of intense decomposition and weathering, continued even at the present day. The maximum thickness of ore-body mentioned by the author is 40 feet. A description is given of the series of chemical reactions by which the author conceives the ores to have been derived from the very rocks among which they now occur. L. L. B.

THE IRON-ORES, ETC., OF AMBERG, BAVARIA, GERMANY.

Die Amberger Erzlagerstätten. *By* ERNST KOHLER. *Geognostische Jahreshefte*, 1902 [1903], *vol. xv., pages* 11-56, *with* 10 *figures in the text.*

Mining operations have been carried on in the neighbourhood of Amberg, in the Upper Palatinate of Bavaria, for more than a thousand years, and at no period during that lapse of time have they been completely suspended. The most important deposits, both from the scientific and the industrial point of view, occur along three great fault-lines striking south-east and north-west through the district. Of less importance are the innumerable "nests" and pockets of brown ironstone, yellow ochre, etc., scattered all over the surface of the Jurassic plateau known as the Alb.

At Amberg, the ores occur in the form of irregular lenticles of brown hæmatite embedded in a mass of steeply-dipping sands and clays, which intervene between the Cretaceous and the highly-disturbed Jurassic strata. In depth, the entire ore-body is seen to increase in thickness, though in a somewhat irregular manner. In 1879, spathose iron-ore was for the first time discovered here; its structure is in part saccharoidal and crystalline, in part cavernous, and the ore is in fact not easily distinguishable by the eye from the dolomite against which it abuts and into which it sometimes passes. The geological conditions appear to be generally much the same farther north, at the Caroline and Etzmannsberg mines. In the last-named, the ore-deposit thickens from 100 feet at the 350 feet level, to 260 feet or more at the 367 feet level, where it can be followed for a length of more than 1,150 feet. It has been proved here that the ore-body is unconformable (geologically) both to its foot-wall and its hanging-wall. The brown hæmatite in this part of the field occasionally passes into red hæmatite.

As one goes south from Amberg, mine-exposures cease to be available, and the ore-deposits finally thin out at Paulsdorf and Altenricht. East of the Amberg fault-line is that of Vilseck-Auerbach, along which are found the mining concessions of Gross Schönbrunn and Minister-Falk, and the Leonie mine. Here again the ore-deposits are associated with the immediate proximity of Jurassic limestones and dolomites. Brown hæmatite has been proved at various depths from 52 to 321 feet, ranging in thickness from 20 to 65 feet; and between Bernreuth and Ritzelbuch, at a depth of 330 feet or so, spathose iron-ore has been struck, 60 feet thick. The borings

just mentioned were put down in the Minister-Falk field, where actual working has not yet been started. Interesting sections are figured of the Leonie mine at Auerbach, where the predominant ore is white to grey spathic iron-ore, while brown hæmatite plays only a subordinate part.

Along the third fault-line, which runs from Eschenfeld through Freihung to Kirchenthumbach, lead-ores occur (among sandstones and marls of probably Keuper age), which are not worked nowadays. The iron-ores also are found along the same line, always associated with Jurassic strata.

After a short description of the "nests" of ochre, etc., on the Jurassic plateau, the author proceeds to consider the question of the genesis of the ores. He concludes that they are unmistakably of metasomatic origin—that is, due to the gradual replacement of limestone by iron-compounds. These were derived from deep-seated thermal waters which welled up through the fault-fissures. These fissures were torn in the rocks in Tertiary times, and the not far-distant basaltic hills of Parkstein, Neustadt-am-Kulm, Oberleinleiter, etc., bear witness to the active vulcanicity of that period, to which the mineralized thermal waters are evidently assignable (post-volcanic phase).

Several chemical analyses are tabulated, the Amberg ores showing percentages of iron-sesquioxide which vary from 71·32 to 85·98.

The "nests" of ochre are regarded by the author as being in some cases, the decomposition-products of the limestones among which they lie. In other cases, they may be the remnants of ramifications of the great fissure-deposits. L. L. B.

THE ORIGIN OF CERTAIN DEVONIAN HÆMATITES IN GERMANY.

Zur Frage nach der Entstehung gewisser Devonischer Rotheisenerzlagerstätten. By E. HARBORT. *Neues Jahrbuch für Mineralogie, Geologie und Paläontologie*, 1903, *vol. i., pages* 179-192, *and plates VIII. and IX.*

It is a fact of common knowledge that the Devonian hæmatite-deposits in north-western Germany almost invariably occur in the immediate neighbourhood of diabasic or schalstein-rocks; further, that they are richer, where these volcanic rocks are highly decomposed. Whence it was inferred that the iron had been exclusively derived from the decomposition-products of the weathered diabases; that it had been carried upward by carbonated solutions into the sedimentaries, and that most of the ore-deposits have been consequently formed by metasomatic replacement of the limestones, etc. But the fact that some hæmatite-specimens include fossils, wherein all the external structure of the organism is preserved in minute detail, is hardly reconcilable with the metasomatic theory; and Prof. Bergeat requested the author to examine various hæmatite-deposits, especially those of the Harz, in the light of this new objection.

He notes, in the first place, that the mass of weathered diabase necessary to supply the iron of hæmatite-deposits, many of which exceed 65 feet in thickness, is out of all proportion to any known occurrence of decomposed volcanic rocks in the regions traversed by him. Then, the stratigraphical evidence of itself condemns the metasomatic theory, as many thin layers of unaltered greenish-grey shale, or pure, compact, pale-grey limestones are in places interbanded with the hæmatites. Further, the hypothesis that the ore-deposits would impoverish in depth (because deeper down, below the general water-level of the country, the metasomatic replacement of the

sedimentaries would be impossible) has proved fallacious. Several deep borings in Nassau have recently struck workable ores far below that water-level.

The author concludes that these hæmatite-deposits are not secondary but primary formations; that they were laid down contemporaneously with the limestones and the tufaceous sediments; and that they must be regarded as belonging to the group of chemical precipitates. This is affirmed only of the Harz, as the author considers that he is not sufficiently acquainted with the hæmatite-deposits of Nassau, Westphalia and Bohemia, to dogmatize regarding them. Still, the hand-specimens, available in the Clausthal Museum, do not fit in with the metasomatic theory. The iron of the Harz hæmatites was doubtless derived in the first instance from the submarine volcanic eruptions of the Middle Devonian Period.

L. L. B.

THE MANGANESE ORE-DEPOSITS OF HESSE AND NASSAU, GERMANY.

Die Hessischen und Nassauischen Manganerzlagerstätten und ihre Entstehung durch Zersetzung des dolomitisirten Stringocephalenkalkes resp. Zechsteindolomits. By RUDOLF DELKESKAMP. *Zeitschrift für praktische Geologie*, 1901, *vol. ix.*, *pages* 356-365.

The manganiferous and hæmatitic deposits of Hesse and Nassau almost invariably overlie either dolomitized *Stringocephalus*-limestone (Devonian) or decomposed Zechstein-dolomite (Permian), they in fact fill up the deep hollows in the uneven surface of these limestones. Moreover, the ores form irregular "nests" of varying size within these rocks, or occupy joints and fissures which cut deep into them. Generally a clay-bed overlies the ore-deposits: these, taken as a whole, form a mass 20 to 40 feet thick of manganiferous brown hæmatite, containing about 45 per cent. of iron and from 7 to 10 per cent. of manganese. Occasionally the main mass of the deposit is pure manganese-ore; or the manganese occurs in "nests" encrusted with brown hæmatite, or as lumps amid a pulverulent mass of the iron-ore. The ore-occurrences are spread over a very extensive area, but are of industrial importance at comparatively few localities. Their geological relationships being practically identical, it may be inferred that all these deposits originated in the same way.

The author describes briefly the mines in the Stromberg district, where a pulverulent mass of manganese-ore is worked, containing in its best parts lumps (up to the size of a man's head) of hard ore with 18 to 22 per cent. of manganese and 28 to 32 per cent. of iron. Proceeding then to the description of the deposits in the Odenwald, he points out that the pyrolusite and brown hæmatite in that area are unmistakably the decomposition-products of the underlying Zechstein-dolomite. The ore-deposits are conformably overlain by impermeable Bunter Marls, etc. The same evidence is forthcoming in north-western Spessart, where the ores occur within the Zechstein itself as well as on top of it, and in the lower portions of the ore-body perfectly fresh dolomitic sphærosiderite has been found. The most important deposit of all is that in the Lindner Mark, near Giessen, where the floor is dolomitized *Stringocephalus*-limestone: the more dolomitized and fissured this limestone is, the richer and more abundant are the ores. The deposit is overlain by clays which the author believes to be

in part of Pliocene age, and he controverts the hypotheses of Messrs. Ludwig and Volger who opined that these clays might be decomposition-residues of the dolomite. He discusses at some length the chemical processes connected with dolomitization, etc. The concluding portion of the paper is devoted to a short description of the ore-deposits of the Nauheim district. There, at the Oberrossbach mine, some of the finest manganese-ores in Germany have been obtained. The average percentages of the ores now worked in that district are 25 to 26 of manganese and 24 to 25 of iron. The best grades contain from 45 to 90 per cent. of manganese dioxide.

L. L. B.

THE MINERAL RESOURCES OF THE TAUNUS DISTRICT, NASSAU, GERMANY.

Die technisch nutzbaren Mineralien und Gesteine des Taunus und seiner nächsten Umgebung. By RUDOLF DELKESKAMP. *Zeitschrift für praktische Geologie*, 1903, *vol. xi., pages* 265-276.

The Taunus range is rich in ore-occurrences, but in many cases these are so widely distributed through the mass of the rocks that the cost of mining operations and the difficulties of transport make the deposits unworkable. The mineral industry has only shown real vitality in the Lahn, Rhine and Wetterau districts.

Argentiferous galena and zinc-blende, generally associated (and with them copper-ores sometimes occur), are largely worked in the neighbourhood of Ems and Holzapfel in the Lahn valley. The infilling of the reefs consists of the above-mentioned ores with quartz, spathose iron-ore and iron-pyrites; they occur amid the clay-slates, quartzites and grauwackés of the Upper Coblentzian (Lower Devonian) series. Near the outcrops the sulphidic ores are, as in so many other cases, decomposed to oxides, carbonates, phosphates, etc. The ore-bodies sometimes appear to be stratified, and sometimes are amorphous masses, the maximum thickness being about 33 feet, although in one case it reaches double that measurement.

Iron-pyrites, slightly auriferous, is of widespread occurrence in the rocks of the Taunus, and this has given rise to many baseless rumours (as, recently, in the neighbourhood of Homburg) of gold being found there.

Iron-ores (red and brown hæmatite), generally manganiferous, and frequently associated with manganese-ores of excellent quality are worked all along the Lahn valley, from Diez to Giessen. The hæmatites vary greatly in texture, and the deposits vary equally in character—some being reefs, others being pockets or nests, and yet others being bedded. The "reefs" or "veins" generally yield brown hæmatite, and occur almost exclusively in the Taunus quartzites. Both iron- and manganese-ores appear to be genetically connected with the occurrence of quartz-veins.

The "beds" and "pockets" of brown hæmatite associated with the Lower Devonian sericite-schists contain from 41 to 47 per cent. of metallic iron; 2 to 2·6 per cent. of manganese; 1 to 2·5 per cent. of phosphorus; and 20 to 28 per cent. of residues (mostly silica).

Of far greater economic importance than the ores just described are the Middle and Upper Devonian red hæmatites. These extend over a considerable area, are interbedded among schalsteins and slates, and vary in thickness from 1 to 6½ feet. Some of the deposits are rendered unworkable because they contain too much lime, others because they contain too

much silica. One of the most considerable and interesting occurrences is that of Oberneisen, where the hæmatite appears in contact with the "Lahn porphyry": the best-grade ore here contains 65 per cent. of metallic iron. Then there are the iron and manganese-ores associated with the dolomitized *Stringocephalus*-limestone, the hummocky surface of which forms the floor or hanging-wall. These oft-described and much discussed deposits often penetrate deep into fissures and hollows of the underlying limestone, and are mantled by a barren cover of drift-sands and clays of varying thickness. The ore-bodies range in thickness from 20 to 40 feet, and lumps of pure psilomelane and pyrolusite are distributed through the crumbly hæmatite. It is noticeable that the more highly fissured and dolomitized the limestone is, the richer and more abundant are the ores. One of the most important mines that work these deposits is situated in the Lindner Mark, south of Giessen: the extensive workings here are opencast. Borings to the north and south have proved vast masses of still unworked ore of excellent quality.

Between Nauheim and Homburg-vor-der-Höhe are the manganese-mines of Oberrossbach and Köppern, where shafts have been put down to a depth of 213 feet, and workable ore still remains below this. The ore contains from 18 to 22 per cent. of manganese, 27 to 33 per cent. of iron, 0·3 to 0·4 per cent. of phosphorus, and 8 to 9 per cent. of residues. But it is much richer in manganese at the outcrop, and this holds good also (in regard to iron) of the accompanying brown hæmatite. A brief description of the not dissimilar ore-deposits of Weiler-West, Bingerbrück, Waldalgesheim, and the Bieberthal is also given, and the author then proceeds to consider the question of their origin. He regards many of them as primarily the result of weathering (decomposition of rocks by atmospheric agencies) but does not exclude the occasional intervention of ferruginous and manganiferous thermal springs; and he points out that the Nassau deposits (at all events) are generally regarded as having been formed by such springs and in no other way.

Brown coal is of frequent occurrence in the Tertiary deposits along the slopes of the Taunus; but in some places the quality, and in others the quantity, of the mineral is apparently not sufficient to justify working. However, about 118,000 tons of brown coal were got in the year 1900, the best being the Pliocene coals of the Friedberg district. The older (Oligocene) coals are much poorer. The quantity of workable brown coal still in sight is estimated at 15,000,000 tons.

Elaborate statistics are tabulated of the mineral output of the Wiesbaden and Koblenz districts and of the Grand Duchy of Hesse during the past six years. L. L. B.

THE MAGNETITE-DEPOSIT OF THE SCHWARZER KRUX, THURINGIA.

Das Magneteisenerzlager vom Schwarzen Krux bei Schmiedefeld im Thüringer Wald. By KARL SCHLEGEL. *Zeitschrift der Deutschen Geologischen Gesellschaft*, 1902, *vol. liv., pages* 24-55, *with* 3 *text-figures, and plates II. and III.*

The magnetite-deposits of the Schwarzer Krux, near Schmiedefeld, were worked for many centuries, and then abandoned in the latter half of the nineteenth century. Somewhere about 1888 an attempt was made to restart mining operations, but it was a purely spasmodic effort, and now the workings have fallen in: the enormous waste-heaps scattered through the forest alone bearing witness to the activity of former generations of miners.

A brief sketch is given of the literature of the subject, and the author

then describes the granite-massif on which the Schwarzer Krux is situated. This granite is presumed to date from Carboniferous times, while the sedimentaries through which it has torn its way are of Upper Cambrian age. The rock is of two varieties—typical biotite-granite and two-mica-granite: both varieties contain tourmaline. Quartz-porphyry dykes course through the granite-massif, and the granites themselves are full of inclusions of quartz-mica rock and hornblende-schist.

The waste-heaps really contain vast quantities of iron-ore which will be industrially available, so soon as the projected railway from Ilmenau to Schmiedefeld is completed. As in the case of the granites, etc., the author made an elaborate petrographical study of the magnetite, examining many scores of microscopic slides. The ore varies considerably in structure from compact, through finely granular, to coarsely crystalline: sometimes it shows traces of schistosity. Fluorspar is invariably associated with it: frequent associates also are wolframite, molybdenite, barytes and pyrites. An analysis of "magnetite-rock" yielded 88·55 per cent. of iron oxides and 9·10 per cent. of manganese oxide.

The ore occurs near the contact with the granite in the metamorphosed clay-slates, and apparently is itself really a metamorphosed hæmatite-deposit. Similar examples, due to contact-metamorphism, are cited from Spitzenberg in the Harz and Angers in the west of France. The fluorspar is no doubt the result of fluoric emanations which would make their way through the fissures in the rocks caused by the irruption of the granite. The occurrence of a garnet-rock rich in fragments of crystalline limestone also points to the former existence of limestone-bands in this locality. L. L. B.

THE ORE-DEPOSITS OF THE MÜSEN DISTRICT, GERMANY.

Der Schichtenaufbau des Müsener Bergbaudistriktes; die daselbst auftretenden Gänge und die Beziehungen derselben zu den wichtigsten Gesteinen und Schichtenstörungen. By MAX BRÖCHER. *Verhandlungen des naturhistorischen Vereins der Preussischen Rheinlande, etc.*, 1902, *vol. lix., pages* 99-134, *with 5 text-figures and plates II.-III.*

The area in question comprizes various groups of high hill-ranges which form a portion of the Siegerland, and all the strata are of Lower Devonian age. They consist of an alternation of grauwackés, grauwacké-slates and clay-slates, all striking uniformly north-east and south-west, and dipping south-eastward at high angles (from 30° to 80°). The bedding is not especially massive, and stratigraphical units approaching or exceeding 16' feet in thickness are of rare occurrence. A detailed description is given of the highly-jointed grauwackés, and of the other strata already mentioned, but a group peculiar to the Müsen district is that of the Red Slates, interbanded at various horizons with the other rocks. They are very flaggy, splintery, and fairly hard (5 in the scale of hardness). Their brown-red coloration is doubtless due to the 10 per cent. or so of iron peroxide which they contain, and moreover that peroxide appears to be the material which has bound the other constituents of the slates together. Taken as a whole, the strata show signs of considerable disturbance and faulting, and the author describes at length the two main fissure-faults of the district: the Stuff and the St. Jakobskluft.

The ore-deposits are defined as independent lenticular veins, showing

great variations when compared one with the other. The author divides them into two categories:—(1) Ironstone-veins, the ore in which is mainly spathose iron and the gangue mainly quartz; and (2) ore-veins proper, containing sulphides of lead, zinc, silver and copper, with heavy-spar as the commonest gangue. At the outcrop, the metallic sulphides are frequently found decomposed to oxides and hydroxides. The veins in some cases represent the infilling of fissures which have been torn in the rocks without any intervention of lateral thrust. In other cases, they are the infilling of true fault-fissures, and in yet others they are genetically connected with overthrust-phenomena.

A short description is given of the most important ore-deposits. In the first place, as regards the iron-ores the Brücher vein, 10 feet thick, has been now worked out, and the same statement holds good of the Stahlberg deposit. The Sonnenberg, Kuhlenberg and Jungermann veins have been worked as far as it would pay, and are now abandoned.

Galena and zinc-blende are got from the Glücksanfang veins Nos. I. and II.; the ores apparently increase in richness and quantity the deeper down they are worked. Similar ores, with, in some cases, fahlores and copper-pyrites, are worked from about a dozen other veins. In the "diagonal vein" there are masses of pure ore 10 feet thick, and the entire ore-body is in places as much as 33 feet thick.

The ore-deposits are invariably cut off or nipped out by the Red Slates: these were in a relatively plastic condition at the time when fissures were being torn in the other rocks, so that fissures could not remain open in them to receive the metalliferous infilling. Later on the now Red Slates were infiltrated with the iron peroxide which has cemented them together. Generally speaking, there is cumulative evidence of a relationship between the fault-folds of the district and the metalliferous veins, as the number, thickness, and character of the latter have been unmistakably influenced by the former. It may be added that the sulphidic ores are very probably of more recent date than the iron-ores in the Müsen district.

L. L. B.

THE IRON-ORE DEPOSITS IN THE WESER HILLS, WESTPHALIA.

Die nutzbaren Eisensteinlagerstätten, insbesondere das Vorkommen von oolithischem Roteisenstein, im Wesergebirge bei Minden. By Dr. Th. Wiese. *Zeitschrift für praktische Geologie*, 1903, *vol. xi., pages* 217-231, *with* 2 *figures in the text.*

At one time clay-ironstones alone were got in the Weser Hills, near Minden in Westphalia, but of late the winning of hæmatite has taken the front rank. It occurs in the Jurassic strata, in the neighbourhood of the famous *Porta Westphalica*, and the mines are connected by a light railway with the main line from Cologne to Minden. Clay-ironstones are still worked in the Wittekind seam, near Bergkirchen, and in the reniform concretions of the Bockshorn gravel-pit at Veltheim-on-the-Weser.

A description, geological and physiographical, of the Weser range of hills, based on Prof. Rœmer's and Dr. Heinrich Credner's monographs, is given by the author. It may be noted in passing that the Wittekind seam is a marly iron-pisolite in the Lower Kelloways rock, dipping near Bergkirchen some 30 to 40 degrees, 3 feet thick, overlain by a band of pyrites which in places is as much as 6½ feet thick, and is in turn overlain by 8 inches more of pisolite. At Lutter, the pisolite is 6 feet thick. The ore contains, on an average, 30 per cent. of metallic iron.

Then follows a detailed description of the "seams" of red hæmatite which occur among the Upper Oxfordian limestones. At the Victoria mine, the lowest ore-band is called the Nammer-Klippen seam; it is oolitic in structure, and contains in its upper portion rather more than 22 per cent. of metallic iron: the total thickness of the seam varies between 33 and 40 feet. An interval of some 3 or 4 feet of blue limestone separates it from the next overlying seam, the Victoria, 6½ feet thick, containing about 40 per cent. (on an average) of metallic iron. Working was started on this seam in 1884, and it is now practically exhausted. Above this follows more blue limestone, 30 feet thick, and then the Joseph hæmatite-seam, in composition and appearance much like the Victoria seam. But, though analyses showed it to contain from 58 to 61½ per cent. of iron peroxide, it proved unworkable, as it thinned out so rapidly. The Lower Kimmeridge limestones and marls form the cover.

At Kleinenbremen, the following hæmatite-seams are recognized, in ascending order: (1) Nammer-Klippen seam, 13 feet thick, containing from 15 to 25 per cent. of metallic iron, as yet unworked; and (2) Wolverwahrt seam (with which among other minerals an anthracitic pyritous coal is associated), 4 feet or so thick, containing in choice samples 46 per cent. or more of metallic iron, and 0·11 per cent. of phosphorus, the average content of iron being from 38 to 40 per cent. This seam continues in depth to the west, but nips out in depth eastward.

The local designation of "seams" is, the author remarks, perhaps in fact hardly applicable to all of these hæmatite-deposits, although they are conformably interbedded with the strata among which they occur, and both as to roof and floor, sharply marked off from them. Microscopic examination shows that the minute structure of the deposits is truly oolitic, and they are in this and in other respects comparable with the Clinton ores. They were laid down in sea-water: so much is proved by the palæontological evidence. He concludes that they originated in the same fashion as the *minettes* or oolitic iron-ores of Luxemburg and Lorraine: iron-salts in solution, brought into the sea by springs or rivers, underwent a series of chemical reactions, the final result of which was the precipitation of the iron in the form of oxides and oxyhydrates. L. L. B.

THE BARYTES-DEPOSITS OF THE RÖSTEBERG, NORTHERN GERMANY.

Die Schwerspathvorkommen am Rösteberge und ihre Beziehung zum Spaltennetz der Oberharzer Erzgänge. By H. EVERDING. *Zeitschrift für praktische Geologie*, 1903, *vol. xi., pages* 89-106, *with* 11 *figures in the text.*

The Rösteberg (1,175 feet above sea-level) is the highest summit of a ridge which marks the boundary between the Palæozoic massif of the Harz mountains and the Mesozoic foot-hills, in the district that lies between Grund and Gittelde. The barytes occurs in apparently-bedded deposits of Permian age forming the very top of the Rösteberg; and a hundred feet or so away, in the Palæozoic slates is the old Hülfe Gottes (God's Help) metalliferous mine, which was worked for many generations. The remarkable occurrence of the Rösteberg crops up again and again in the scientific literature dealing with the Harz, a short summary of which is given. After a fairly-detailed description of the barytes-deposits as seen in several small

quarries opened up to work it, the author proceeds to consider the vexed question of its origin. All the evidence that he can adduce points to its genesis through metasomatic replacement of the Zechstein Limestone, brought about by the active circulation of thermal waters carrying barium, etc., in solution.

It has been shown that pure barytes is being formed in certain Westphalian collieries at the present day, by the interaction of pit-waters, some containing barium salts and the others sulphates in solution, and this is in localities where the Carboniferous is much disturbed by cross-faulting. The Rösteberg mineral is in truth genetically connected with the fault-fissures, some of which in the immediate neighbourhood were infilled with metalliferous ores; and this faulting probably originated at the same time and from the same causes, both within and without the orographic boundary of the Harz massif. But the Rösteberg faults are at any rate post-Permian, since the Permian strata have been disturbed by them; therefore, too, all the metalliferous veins of the Upper Harz are post-Permian (including the God's Help vein). The long process of mountain-building, in the case of the Harz, may well have lasted from the close of the Devonian into Tertiary times. Whether the metalliferous veins occupy fissures first formed during the latest movements, or whether these fissures really date back to the earlier movements, and were continued and re-opened by the later, is a point still in dispute. L. L. B.

ORIGIN OF THE PYRITES-DEPOSITS OF RAMMELSBERG, GERMANY.

Ueber merkwürdige Einschlüsse im Kieslager des Rammelsbergs bei Goslar. By ALFRED BERGEAT. *Zeitschrift für praktische Geologie*, 1902, *vol. x., pages* 289-293, *with 2 figures in the text.*

In contradistinction to Prof. Vogt's view that the Rammelsberg ore-body is of the nature of a vein-deposit, the author holds that it cannot possibly be anything else than a true bedded deposit, which was formed contemporaneously with the Wissenbach slates and is a member of that series of strata. In support of this opinion he adduces fresh evidence in the shape of masses of iron-pyrites, smooth and reniform, which occur amid the so-called "mixed ore" (alternating bands of fine grained chalcopyrite and galena) of Rammelsberg; these are unmistakably concretions formed within a sedimentary bed, and would of themselves be sufficient to dispel the notion (if it were otherwise admissible) that the pyrites-deposits near Goslar were the outcome of the metasomatic replacement of limestone. L. L. B.

PRECIOUS OPAL OF DILLENBURG, GERMANY.

Opal in der Gegend von Dillenburg. By — LÖCKE. *Zeitschrift für praktische Geologie*, 1903, *vol. xi., page* 303.

The author recently discovered precious opal in a freshly opened exposure of eruptive diabase on the right bank of the Irrschelde valley, 2½ miles north-east of the village of Oberscheld, in the district of Dillenburg (Nassau).

The mineral occurs in bluish to milk-white lumps, varying in size from that of a hazelnut to that of a walnut, in small "nests" in the diabase, sometimes intergrown with red hæmatite. The opal showed conchoidal fracture and (in places) most brilliant iridescence.

In some cases crystalline quartz was associated with it. L. L. B.

THE NICKEL-ORES OF SOHLAND, SAXONY.

Ueber eine neue Nickelerzlagerstätte in Sachsen. *By* DR. R. BECK. *Zeitschrift für praktische Geologie*, 1902, *vol. x.*, *pages* 379-381.

The author recently announced the discovery of nickel-ore deposits in the neighbourhood of Sohland, district of Lausitz. Meanwhile, exploration-work has proceeded apace, yielding new information as to the geological conditions of the occurrence. A dyke of igneous rock, defined by the author as an olivine-proterobase rich in biotite, some 33 feet thick, strikes west-north-westward through the Lausitz granite, and its northern salband has been traced for about 2,300 feet. The ore occurs at the junction of the proterobase and the granite, dying out into either rock into a mere impregnation, and then disappearing altogether. At the bottom of the Herberg exploration-shaft, the ore-band attains thicknesses of 5 to 8 feet, but it dwindles towards the outcrop to a few inches. Where the igneous rock is least decomposed the ore is mainly (nickeliferous) magnetic pyrites; nearer the surface, in proportion as the igneous rock is more decomposed and broken up into spheroids, copper-pyrites, and then malachite and limonite make their appearance, forming often the cementing-material of the spheroids of semi-decomposed igneous rock.

In the richest parts, the percentage of nickel varies between 4 and 5, in association with 2 per cent. of copper. This compares favourably with Canadian ores of a similar character. So far, a depth of only 35 feet below the surface appears to have been reached, but it is believed that the ore goes down to at least double that depth. A second shaft has been sunk close to the Saxon frontier, and the indications are promising, although the granite-junction has not yet been struck. L. L. B.

PHOSPHORITE-DEPOSITS OF THE VOGTLAND, SAXONY.

Die Phosphoritführung des Vogtländischen Obersilur und die Verbreitung des Phosphorits im Altpalaeozoicum Europas. *By* L. KRUPT. *Neues Jahrbuch für Mineralogie, Geologie und Paläontologie*, 1902, *XV. Beilage-band*, *pages* 1-65, *and plates I.-II.*

The three groups into which the Upper Silurian of the Vogtland is divisible, namely the Alum-shales, the Ochreous Limestone, and the Siliceous Shales, are all known to contain phosphates in a finely divided state; but the Siliceous Shales, and more especially the Alum-shales, are characterized by the occurrence (in places very abundantly) of phosphorite-nodules.

The nodules vary greatly in size and shape; they are black when freshly extracted from the matrix, but weather ultimately to a light-grey. Sometimes they coalesce into slabs of reniform concretions some 2 inches thick, and they are invariably tough and difficult to smash up.

The author made a series of careful chemical analyses, which yielded (in the case of the Leuchtsmühle, Plauen and Pöhl phosphorites) about 37 per cent. of phosphoric acid and from 25 to 45 per cent. of lime, the other principal constituents being silica, alumina, magnesia and iron. Traces of iodine were detected in most instances, and fluorine in one. The average specific gravity of the mineral is 3·01.

The nuclei of many of the nodules consist of fossil organisms (crustacea, graptolites, cephalopoda, radiolaria, etc.), the hard portions of which have been converted into phosphorite. Where the shales contain these nodules

they are no longer phosphatic; but, as above-hinted, the shales are distinctly phosphatic where the phosphorite-nodules do not occur. This gives a clue to the genesis of the deposits. The organisms decomposing amid the mud of the Silurian sea-floor gave rise to an evolution of carbonic acid, which dissolved out the phosphate of lime whereof their endo- or exo-skeletons were partly made up; this phosphate was replaced by the less easily-soluble phosphate of lime from the sea-water, which tended gradually to accrete around such organic nuclei in the from of an ever-thickening crust or nodule. From the algæ in the sea-water the omnipresent iodine was evidently derived.

The author points out that similar phosphorites occur in the Upper Silurian of neighbouring districts, and he gives a brief description of all such occurrences in the older Palæozoic of Europe generally, from the Lower Cambrian to the Upper Devonian inclusive. No information is to be gleaned from the paper as to the working (actual or prospective) of the Vogtland and other deposits. L. L. B.

GENESIS OF THE ORE-DEPOSITS OF UPPER SILESIA.

Zur Genese der Oberschlesischen Erzlagerstätten. By G. Gürich. *Zeitschrift für praktische Geologie*, 1903, *vol. xi., pages* 202-205, *with* 1 *figure in the text.*

From a recent study of the "main ore-body" or lower horizon in the Beuthen basin, the maximum thickness of which is 40 feet, the author arrives at the conclusion that the same causes as those which brought about the dolomitization of the limestone country-rock also brought about the deposition of the ores themselves (galena, marcasite, zinc-blende and calamine). He considers that all these were present in solution in the Triassic Sea, not that they welled up through the fault-fissures in the rocks. The dolomite and the associated ores occur not only in the Beuthen basin, but to the south-east in Galicia (Trzebinia and Krzeszowice), and to the north-east in the Tarnowitz basin, stretching thence into Poland. Fault-fissures, it is true, are not wanting over this vast extent of country, but there is an equally faulted region of Muschelkalk to the west, without a trace of dolomitization or ore-deposition. L. L. B.

COBALT-ORES IN THE THÜRINGERWALD, GERMANY.

Neue Kobaltaufschlüsse im Thüringerwalde. By P. Krusch. *Zeitschrift der Deutschen Geologischen Gesellschaft*, 1902, *vol. liv., Protokolle, pages* 55-58.

The most important cobaltiferous veins in the Thuringian Forest are those of Schweina-Glücksbrunn, described in detail by Dr. Beyschlag.* They form the infilling of fault-fissures in the Zechstein series, and the metalliferous impregnation extends upward into the limestones as well as downward into the conglomerates of that series. The thickness of the veins is extremely variable, but the richest are generally those of medium thickness. Mining industry, which had been active in the district ever since 1720, was brought to a standstill in 1850, because means were not then available for carrying on deep-level workings. Within recent years, however, there has been a revival, and a new cobaltiferous vein has been struck. This, the so-called Beyschlag reef, carries smaltine with a gangue of heavy-spar, and ranges in thickness from a few inches to 5½ feet. A percentage analysis of the ore yielded the following result: Cobalt 10·93,

* *Zeitschrift für praktische Geologie*, 1898, *vol. vi., page* 1.

nickel, 6·12, arsenic 75·04, iron 5·22, copper 0·31, and sulphur 1·61, corresponding to the formula $Co(Ni)_2As_5$. Attention is drawn to the high percentages of nickel and arsenic.

The discovery is of considerable importance for the German colour-manufacturers, as most other cobalt-ore deposits in Germany have been worked out, and manufacturers have been perforce dependent on imports of foreign ores.

Meanwhile exploration-work is going on in the neighbourhood of Königsee, where highly-fractured masses of Zechstein are faulted down against the Cambrian formation. The decomposed relics of cobaltiferous veins have been found, but search is directed to unaltered deposits, and the author seems to view the prospect as hopeful. L. L. B.

THE POTASSIUM SALTS OF GERMANY.

The Potassium Salts Industry of Germany. By E. MACKAY-HERIOT. *The Engineering and Mining Journal* [*New York*], 1901, *vol. lxxii., pages* 462-463.

The discovery of natural potassium salts in large quantities in Germany has given rise to a new and flourishing industry. The laws of ownership vary in the different states: in Old Prussia, the salts belong to the man who first demonstrates a payable deposit to the Government; in Hanover, they belong to the landowner; whilst in Brunswick and other States they are a Government monopoly.

Several theories of the origin of these large salt-areas have been framed, but modern theory teaches that the salts were originally precipitated from sea-water. It is unlikely that they resulted from other salt-formations after these had been dissolved, because the foot-wall is generally anhydrite and limestone, which can hardly have been explained except by assuming the ocean as the source. But the great depth of the North German salt-areas points to the conclusion that one filling of a basin could not have been responsible for such immense deposits, and the ocean cannot therefore be taken as the direct origin. It is much more likely to have been an inland sea either temporarily disconnected from the ocean by a bar, or the bar would let just as much salt-water pass through as could be evaporated by the tropical heat of the Upper Permian era. In the first case, the bar would be closed either by raising or sinking actions, or by heaping up of masses, such as sand. All these obstructions might in time be washed away, and thus permit a new filling of the sea-basin. This process could often be repeated.

The North German salt-deposits may be classified into two types as regards occurrence. The Stassfurt type is marked by its regularity of occurrence, and has but one layer of potassium salts. The Hanover type differs from the Stassfurt type in that several layers or nests of potassium salt are found, and often differing from each other in composition. All the paying deposits of these salts in Germany have been found in the Upper Permian formation. X. Y. Z.

BORINGS FOR SALT IN BADEN, GERMANY.

Die Tiefbohrungen auf Steinsalz in Baden im Vergleich mit denen in Franken. By DR. OTTO M. REIS. *Zeitschrift für praktische Geologie*, 1902, *vol. x., pages* 187-190.

Borings put down near Dürrheim, in the Grand Duchy of Baden, have shown that the thickness of the Middle Muschelkalk in that neighbourhood

averages 280 feet. This formation contains rock-salt, anhydrite and gypsum-deposits, both in Würtemberg and Bavaria, as well as in Baden; and the author's main purpose is to correlate the salt-bearing strata in those three States of the German Empire.

The main anhydrite-bed (with salt-impregnations) at Dürrheim has an average thickness of 82 feet. The corresponding bed is much thicker in Franconia, but there contains no salt. In both regions, however, the important (true) salt-bearing stratum is found much lower down: it is capped by a band of anhydrite (thinner in Baden than in Franconia), and including clay-partings, etc., attains a thickness of about 100 feet. A clay-and-anhydrite parting about 20 inches thick is so continuous over the entire area, being proved at Heilbronn as well as at Dürrheim, that it is held to represent a widespread geological episode; possibly the after-effects of an interruption of the sequence of deposition by the inflow of sea-water or fresh water. The rock-salt above this parting diminishes in thickness and purity from Dürrheim eastward; indeed for some distance north-east of Schwenningen, the borings put down failed to strike salt at all. L. L. B.

BORINGS FOR ROCK-SALT IN BRUNSWICK AND HANOVER.

(1) *Ueber die Bohrungen auf Kalisalze im Norden der Stadt Braunschweig; and*
(2) *Ueber die Ergebnisse einer Bohrung auf Kalisalze bei Vorie an der Bahn Hannover-Altenbeken.* *By* J. Kloos. *Zwölfter Jahresbericht des Vereins für Naturwissenschaft zu Braunschweig*, 1902, *pages* 60-67.

Both these papers emphasize the unhappy results of speculative borings, undertaken in defiance of the geological probabilities which can be postulated from the careful study of the tectonics of any given area. In the Province of Hanover, boring for rock-salt was at first confined to those districts where the Bunter Sandstone overlies the salt-bearing Zechstein. As these districts became completely parcelled out among concessionaires, speculators turned their attention to areas where the Bunter Sandstone is replaced by the next later formations, Muschelkalk and Keuper. From that moment all regard for scientific methods of procedure was cast to the winds, and borings were put down on the rash assumption that where one series of strata was exceptionally thick, the next underlying would have proportionately thinned out, and that consequently the salt-bearing beds would always be struck at somewhere about the same depth! [So much for the marvellous German "efficiency" which is constantly being dinned into British ears at the present day.] Soon the borings were extended even to districts of the North German plain where the Keuper is absent, and the Cretaceous immediately underlies the Tertiary and Drift-deposits: in a few isolated instances these were successful. Many, on the other hand, were stopped in barren strata at depths of 1,600 and 1,900 feet.

The author describes the Cretaceous and Jurassic fossils obtained from the boring-cores, and lays stress on the scientific interest of the borings, which is, of course, unaffected by their failure from the industrial point of view.

L. L. B.

THE MINERAL WEALTH OF THE GERMAN COLONIES.

Die nutzbaren Bodenschätze der Deutschen Schutzgebiete. By A. Macco. *Zeitschrift für praktische Geologie*, 1903, *vol. xi., pages* 28-33 *and* 193-202, *with a map in the text.*

Northern Togoland.—A hill, which rises nearly 800 feet from the plain, north-west of Bányeri, consists almost entirely of massive hæmatite, seamed by quartz-veins. Analysis shows 98·43 per cent. of iron peroxide, 1·54 of silica, and 0·03 of phosphorus pentoxide. Whole hills of hæmatite are also reported to exist at Kabu and Bássari.

Central Togoland.—Lenticles of red hæmatite interbedded with the quartzites of the Santrokofi-Akpafu range yield on analysis 78·4 per cent. of iron peroxide, 10·5 per cent. of silica, 0·73 of phosphorus pentoxide, and 9·98 of water.

Kamerоons.—Gold is reported from the neighbourhood of the Edea falls, and in Aboland gold and silver have been found in very small quantities. Limonite is of widespread occurrence in lateritic deposits, and copper-ore has been reported from Baliland. An expedition has been sent out to study the German territory in the Benué region from the economic point of view. Tin-ore certainly occurs in that area, but how and where the natives work it is as yet unknown. Native sulphur, the product of a still active *solfatara*, is found in considerable quantity on the northern slopes of the Kameroon range.

German South-west Africa.—Important finds of native gold are recorded from the river-beds in a few localities, but gold *in situ* is always associated in that region with other ores. For example, with bismuth at several points along the lower course of the Kuisib river, and near Gaogos; with copper along the course of the Swakop. At Potmine only, on the last-named river, has an adit been driven to some depth, when the deposit was found to become completely barren of gold. The surface-indications in the Rehoboth district awakened great hopes in the early eighties. These have not been fulfilled so far, but enhanced facilities of transport (when the railway replaces the ox-waggon), and the provision of a fair amount of capital, may make it possible to work certain gold-reefs there at a profit. The gold occurs in quartz-veins seaming the mica-schists, and is associated with copper-ores. The percentage of gold varies from 3 to 20 parts in a million, and of silver from 20 to 362 parts. Pure copper-ores without a trace of gold, occur at Angra Pequeña, Aos, etc. At Gorup, the ores are both auriferous and argentiferous. Much exploration and prospecting-work has been done, but mining operations have not been seriously started as yet, at the so-called Hope mine, south-east of Walfisch Bay. At the Matchless mine, 105 miles east of Gorup, the now dormant mineral-industry may well be quickened into life again when the projected railways are built.

In the Otavi district there is a great spread of limestones wherein copper-glance and galena occur in apparently payable quantities. Magnetite-deposits have been noted in the gneiss of Angra Pequeña, Ugama, Aos, etc.

The famous diamond-bearing "blue ground" stretches from British into German territory, where typical occurrences of it have been noted in four localities. Coal has not yet been struck, and such graphite as occurs would not repay working.

Marble of promising quality, and of all hues varying from pure white to deep black, is found at several localities in the immediate neighbourhood of the Swakopmund and Windhoek Railway.

German East Africa.—The Colonial Administration has reserved to itself

the right of working or leasing the gold-placers which undoubtedly exist along some of the watercourses. Some leases were granted about the end of 1902, covering a number of streams which flow into the Victoria Nyanza. Gold-reefs occur on the Iramba plateau, but one gathers that they would hardly repay working under present conditions. The same statement appears to apply to the copper, lead and iron-ores reported from various localities. Coal occurs in the Karoo Beds on the shores of Lake Nyassa, but not in the workable seams on the eastern shore; while on the north-western shore, on the right bank of the Kiwira, there is a bottom seam 16 feet thick, two seams 16 feet thick, two seams rather more than 6½ feet thick, and one 5 feet thick. The coal-formation crops out here for a distance of more than 9 miles, strikes north and south, and dips gently eastward. As one approaches the British border the seams appear to thin out. Three qualities of coal are distinguishable: a lustrous, graphite-like, specifically light, non-stratified mineral; a compactly-bedded, heavy, bituminous mineral; and a shaly, generally light, but sometimes pyritous coal. The first-named usually forms the thickest part of the lowermost seam; the bituminous coal has been struck in four different seams at various horizons, and alternates with the third variety in quite a number of other seams. Samples have only been taken so far from the outcrops, and so it is not surprising to learn that the percentage of ash is rather high, The heating-power of the bituminous coal alone is stated to exceed 6,500 calories.

Workable deposits of mica occur in the Uluguru range, and garnets, with a tinge of bluish-red and extraordinarily high refractive power, are found among the weathered hornblende-gneisses of the Namaputa district.

Sub-fossil gum-copal is found in considerable quantities in sandy soil in the coast-districts.

Kaiser Wilhelms-Land [*Pacific Ocean*].—Besides gold-placers, platinum-bearing basalts and coal have been proved. In the Palau and Marschall Islands are vast deposits of phosphates.

China.—The author winds up the tale of the German colonies with a sketch of the mineral resources of Shantung, modestly regarded as the *hinterland* of Kiaochau. On October 30th, 1902, the first railway-train loaded with the coal worked by a German syndicate at Weihsien, entered Tsingtau station. The quality of the mineral is about midway between good Westphalian and the best Japanese coal, and it has given satisfactory results when tried on board the German squadron. The greatest coal-field in the province appears to be that of Poshan-Puki-Putsun (170 miles distant from Tsingtau). The coal-basins of Heishan and Hsiho, south and east of Poshan, have been completely worked out by the Chinese. The Laiwu coal-field lies in a mountain-district apparently difficult of access. Along the Hsiau-wönnho valley is a 20 miles belt of Coal-measures, with a seam of good bituminous coal, 6½ feet thick. Brief references are devoted to the coal-occurrences of Ichaufu, Tsau-chuang and Küchau. L. L. B.

BROWN COAL IN GREECE.

(1) *Neue Braunkohlen in Griechenland; and*

(2) *Ueber einen Retinit in Thessalien. By* C. ZENGELIS. *Tschermak's Mineralogische und Petrographische Mittheilungen, n.s., vol. xx.* (1901) *pages* 355-356.

The most important of the coal-deposits recently discovered in Hellenic territory are those of Thessaly, Halonesos and Ḳumi. The Thessalian

mineral is hard, brittle, pitch-black, lustrous, and easily combustible. It has a specific gravity of 1·302, and its conchoidal fracture is so well-marked as to place it alongside jet. The other coals are, properly speaking, lignites, dark-brown, fibrous, and fairly tough. The Kumi lignite is now being successfully used for producing generator-gas to heat the retorts of a sulphur-refinery in the neighbourhood of Athens. Chemical analyses of the coals and lignites yielded the following results:—

	Bituminous Coals from Thessaly.				Brown Coals or Lignites from			
					Kumi.		Halonesos.	
	Dried in Air.		Dried at 221° to 230° Fahr.		Dried in Air.	Dried at 221° to 230° Fahr.	Dried in Air.	Dried at 221° to 230° Fahr.
	A.	B.	A.	B.				
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Hygroscopic water..	8·27	12·00	—	—	10·03	—	10·51	—
Carbon	68·00	65·40	73·97	73·91	48·86	54·06	53·84	60·16
Hydrogen	3·82	3·64	4·16	4·14	4·24	4·72	3·52	3·92
Nitrogen	0·82	0·77	0·89	0·87	0·65	0·72	0·65	0·72
Sulphur	2·30	2·17	2·48	2·46	2·07	2·30	1·75	1·95
Ash	2·45	2·35	2·69	2·67	10·40	11·55	4·19	4·67
Coke	62·53	59·62	68·19	67·75	53·87	59·85	53·00	59·21
Calorific power:—			Calories.	Calories.				Calories.
Calculated ..	—	—	6,672	6,660	—	4,615	—	5,627
Determined ..	—	—	7,112	7,097	—	5,382	—	5,902

Following upon the discovery of the coal in Thessaly in 1900, a variety of the mineral retinite was found in the same province, near the village of Vlachokastania. It is yellowish-red, almost completely opaque, hard, and tough, with a specific gravity of 1·0023. It is easily ignited, and burns well, with a smell of burning amber. At temperatures above 528° Fahr., it begins to melt and to decompose. Chemical analysis showed that it contains 78·47 per cent. of carbon, 9·23 of hydrogen, 10·6 of oxygen, and 0·39 of sulphur. Its calorific power is estimated at 9,056 calories. It yields 1·47 per cent. of ash, and from it by solution in turpentine-oil a good adhesive varnish can be made. The chemical formula to which it most nearly approaches is $C_{10}H_{14}O$, which is that of many ethereal oils and resins.

L. L. B.

THE COAL-FIELD OF DUTCH LIMBURG.

Le Bassin Houiller du Limbourg Hollandais. By A. HABETS. *Annuaire de l'Association des Ingénieurs sortis de l'École de Liége*, 1901, *series* 5, *vol. xiv.*, *pages* 233-263, *and* 2 *plates*.

This paper begins with a brief history of the recently-revived coal-industry of Dutch Limburg; and we learn that, as far back as 1113, the Abbots of Rolduc possessed coal-workings on the banks of the Worm. Of late years, considerable extension of the field in a north-westerly and northerly direction has been proved by boring, and by an Act of the Dutch Legislature of July 12th, 1901, the State has reserved for its own use an area of about 36,000 acres. Certain other areas already conceded are, moreover, to revert to the State in 1945.

The author publishes on a reduced scale a copy of the section and map drawn by Mr. C. Blankevoort, the engineer who superintended the borings on behalf of the Government of the Netherlands. These borings, to the number

of 70, are spread over an area of about 78 square miles, and the evidence at present available is, therefore, not quite sufficient to admit of an exact section of the coal-field. There are doubtless many more irregularities and disturbances than can be pictured from the data supplied, and the author points out that it is not often in this area that the seams proved in one boring can be absolutely correlated with those proved in the next.

He gives in an appendix details of the 70 aforesaid borings, about a dozen of which failed to strike the coal, and he considers that the only classification of the seams that is possible at present is one based on chemical analysis. Just as in the coal-fields of Westphalia and Aix-la-Chapelle, the coals may be grouped from top to bottom of the series according to the decreasing proportion of their volatile constituents. In this way he plots out a map, showing that the highest belt of coal ranges along the northern boundary of the field (gas-coal with 30 per cent. of volatile matter). He recognizes the existence of a fault forming the eastern boundary, running in the same direction as the Feldbiss fault, which has been traced for several miles in the Aix-la-Chapelle basin, separating the anthracitic seams of the Worm district from the bituminous seams of the Alsdorf district. He does not altogether concur with Mr. Blankevoort's mapping of the boundaries and fault-lines, and gives in detail the reasons for differing from that engineer. L. L. B.

ANTIMONY-ORES OF CETINE DI COTORNIANO, TUSCANY.

Cenni sui Minerali della Miniera di Antimonio delle Cetine di Cotorniano. By G. D'ACHIARDI. *Atti della Società Toscana di Scienze Naturali, Processi Verbali*, 1901, *vol. xii., pages* 232-236, *with* 1 *figure in the text.*

The antimony-mine of Cetine di Cotorniano, in the province of Siena, was worked for the first time in 1878. The deposit is a few hundred feet away from the high road betwen Siena and Massa Marittima, a little beyond the gorge which near Rosia cuts through the Montagnola Senese. It consists of a band of chalcedonic quartz and stibine at the junction between the Permian sandstones and the Rhætic limestones (thought by Mr. B. Lotti to be possibly Eocene). The last-named become visibly more siliceous as the junction is approached: whence it may be inferred that quartziferous and antimoniferous thermal springs, flowing up through the sandstones without altering them, in part dissolved away the limestone, the present ore-deposit being thus metasomatic in character. The stibine is distributed in it very irregularly, there being some points where the ore is concentrated in rich masses, and others where there is scarcely a trace of ore. The strike is nearly due east and west, and the mass is split by fissures running north and south, containing red oxysulphide and white oxide of antimony. In some places the quartz is cavernous, and impregnated with much native sulphur.

Detailed descriptions, from the mineralogical and crystallographic point of view, are given of the stibine, stibiconite or antimony-ochre, cervantite, chermesite, sulphur, quartz, calcite, and gypsum found here.

L. L. B.

ANTIMONY-ORES OF CAMPIGLIA SOANA, PIEDMONT.

Il Giacimento Antimonifero di Campiglia Soana nel Circondario d'Ivrea. By V. NOVARESE. *Bollettino del Reale Comitato geologico d'Italia*, 1902, *vol. xxxiii., pages* 319-332.

At the head of the valley of Soana di Campiglia, in the district of Ivrea, the observer's attention is attracted by some "raddled" rocks, which are in truth the limonitic gossan of an ore-deposit, consisting of sulph-antimonites of lead, iron, copper and silver. The mineral-outcrop runs for about 1¼ miles parallel with the stratification of the finely-schistose gneisses among which it occurs, north—60° to 70°—west. These fine gneisses appear to be a local intercalation among the cyclopean masses of the porphyroid-gneiss of the Gran Paradiso. The ore-body really consists of several groups of quartz-reefs, superposed at intervals through a thickness of about 1,000 feet of gneiss. The exploration-work so far accomplished is small, in comparison with the extent of the deposit; but the precipitous nature of the crags among which the ore-body occurs, and the formidable screes under which it lies buried on the gentler slopes combine to make such work very difficult.

At one time stibine was thought to be the chief antimony-ore present: in reality it occurs only in very small quantities, and it would appear that what was mistaken for it is a ferriferous variety of jamesonite. This is a steel-grey, highly-fibrous mineral of specific gravity 5·48, and hardness 2 to 3. Analysis shows it to contain 34·22 per cent. of antimony, 40·21 per cent. of lead, 3·62 per cent. of iron, 21·27 per cent. of sulphur, and minute proportions of copper, silver and gold. The author enters into an elaborate comparison and study of the analyses, appearing rather to favour the hypothesis that the mineral consists of a combination of 5 molecules of berthierite with 3 molecules of boulangerite, expressed by the following chemical formula:—$5(Fe\,Sb_2\,S_4)\,3(Pb_5\,Sb_4\,S_{11})$. Intimately associated with it is a fahlore, brittle, of a bright grey when fresh, yellowish or iridescent when altered by atmospheric agencies, of a hardness greater than 3. It is a tetrahedrite conspicuously rich in silver, and analysis has also shown it to contain copper, but no lead. Pyrites occurs in lenticles, always clearly separable from, and never mixed with, the sulph-antimonites: and the presence of galena is traceable among the old waste-heaps. The deposit is said to have been first discovered about 1869, but it may well have been worked for silver in ancient times, of which there is now no record. L. L. B.

THE ASPHALT-DEPOSITS OF RAGUSA, SICILY.

Über das Asphaltvorkommen von Ragusa (Sizilien) und seine wirthschaftliche Bedeutung. By DR. H. LOTZ. *Zeitschrift für praktische Geologie*, 1903, *vol. xi., pages* 257-265, *with 5 figures in the text.*

The "compressed asphalt" from Ragusa has given especially good results when used as a paving-material in Germany, so much so that municipal contracts in that country are let out in most cases with the express stipulation that Sicilian material shall be used. It is currently termed "asphalt," but, as a matter of fact, it is a bituminous limestone. In this paper, the author adopts the current phraseology for simplicity's sake, and restricts the term "bitumen" to sundry complex constituents which are soluble in carbon-bisulphide.

Ragusa, a town of some 30,000 inhabitants, is situated on a high plateau

of Miocene limestone, in the province of Syracuse, in the south-eastern angle of the island. The plateau is cut off by a fault, with a downthrow of many hundred feet, from the fertile plains of Vittoria and Comiso (made up of Pliocene deposits) on the west and from the plain of Catania on the north-east; but the Miocene limestones and marls slope gradually to the south-east. Basalts and volcanic tuffs, connected with the Pliocene deposits, occur along the fault-line, rising in Monte Lauro to a height of 3,034 feet above sea-level.

The pure-white Lower and Middle Miocene limestones, with marly intercalations and siliceous lenticles, are at least 1,800 or 1,900 feet thick; while the sulphur- and gypsum-bearing Upper Miocene is all but entirely absent from this part of Sicily. The limestones (including the asphalt) are sparsely fossiliferous, but evidently of marine origin. The asphalt-quarries extend for 1½ miles along the upper margin of the Val Ermineo, and also occupy a narrow belt on the rim of the plateau itself towards the east. The asphalt-outcrops are not easily recognizable at first sight, as the mineral on exposure to the air is quickly encrusted with a thin white film, and thus looks exactly like the associated limestone. This weathered surface-mineral is locally termed *albame*, the less weathered (containing from 7 to 8 per cent. of bitumen) *gerbina*, while the better quality (of real commercial value) contains 10 to 18 per cent. of bitumen, and varies in colour from chocolate-brown to nearly black. The deposits vary greatly in quality and in the amount of barren limestone-cover from quarry to quarry. In some cases, they are worked opencast: in others, it is found necessary to drive adits some distance into the hillside. Still, it has been proved that the asphalt does not extend westward far into the plateau—the "linear" extension of the occurrence is one of its main characteristics, and throws some light on its origin. "Horses" of limestone are frequently found in the midst of the richest asphalt, and sometimes beds of asphalt and limestone alternate repeatedly. The rocks are much fissured and shattered, but there is no certain evidence of considerable overthrust.

Rejecting Prof. Coquand's views in regard to the genesis of the Ragusa asphalt, the author holds that, like other bituminous deposits described by Messrs. Malo and Delano, it is the result of the sublimation or upward percolation through fissures of gaseous or liquid hydrocarbons. These were probably derived from the decomposition of organic remains, vegetable or animal, perhaps more likely the former. The impregnation of the limestones with this bitumen is supposed to have taken place in Pliocene times.

The asphalt-industry is of the greater importance for Sicily that sulphur-mining there is in a moribund condition. The new industry employs at present 1,000 workpeople. The mines owe to their high situation freedom from the fevers of the lowlands; but, although work goes on summer and winter alike, the innumerable saints' days and holidays bring the number of actual working-days in the year down to 180. In 1901, the production of asphalt amounted to 75,270 tons, and of bituminous limestone (used locally for building purposes) to 4,100 tons. The output has increased enormously within the last 10 years, but on the other hand prices have fallen by 33 per cent. The neighbourhood of the sea and cheap freights have favoured the worldwide distribution of this output. Next to Germany, the United States and France are the most important customers.

L. L. P.

BAUXITE IN ITALY.

Der Bauxit in Italien. By VITTORIO NOVARESE. *Zeitschrift für praktische Geologie*, 1903, *vol. xi.*, *pages* 299-301.

Bauxite has been vainly sought for many years in Calabria. In 1900, great masses of it were discovered by mere chance, at several localities in the Central Apennines, and the discovery was published by Prof. Mattirolo in May, 1901.

The Central Apennines consist mainly of huge massifs of Mesozoic limestone, ranging uninterruptedly in age from the Trias to the Upper Chalk and capped by the Eocene Nummulitic limestone. The bauxite occurs among the Urgonian or *Caprotina*-limestones (Cretaceous), at practically the same horizon as the bauxite in Southern France, in very extensive beds varying in thickness from 3¼ to 26¼ feet. The mineral varies in colour from deep brownish-red to yellowish-red, light-pink or cream, is soft or crumbly, heavy (specific gravity 2·95 to 3·45), and of a peculiar pisolitic structure. The pisolitic spherules range in diameter from 0·04 to 0·40 inch. The mineral is evidently of the same age as the limestone-beds among which it is intercalated. Five analyses of the bauxite (from Lecce dei Marsi, Pietraroja, Pescosolido and Rocca di Mezzo) are tabulated, showing the percentages of alumina to vary from 47·44 to 58·85, and of iron sesquioxide from 18·62 to 36·37. Silica and titanium oxide are invariably present, but only one sample yielded phosphorus pentoxide (0·02). The Italian bauxite is rich in titanium, like some of the French bauxites and is easily attacked by sulphuric acid.

The author describes the deposits of Lecce dei Marsi and Pescosolido, both of which localities are favourably situated in regard to transport-facilities. They are practically untouched so far, only some preliminary exploration-work having been done on them—sufficient, however, to show that there is enough mineral in sight to supply the whole of Europe for many years to come. L. L. B.

CINNABAR-DEPOSITS OF MONTE AMIATA, TUSCANY.

(1) *Sulla probabile Esistenza di un Giacimento Cinabrifero nei Calcari Liasici presso Abbadia San Salvatore* (*Monte Amiata*). By B. LOTTI. *Bollettino del Reale Comitato Geologico d'Italia*, 1901, *vol. xxxii.*, *pages* 206-215, *with* 1 *figure in the text.*

For more than 50 years the innumerable fragments of cinnabar disseminated in the detritic deposits which occupy a long belt of ground near Abbadia San Salvatore have stimulated prospectors to search for the original *locus* of the ore. These researches have been lately systematized, with the result of arriving at what is no longer a mere probability, but a practical certainty, in regard to the site of the cinnabar-deposits.

A detailed description is given of the stratigraphical succession in this area. In descending order, it is as follows:—

9. Pliocene marine shelly clays and sands.

8. Upper Eocene shales and marly limestones (with the latter, at Il Siele and Le Solforate, are intercalated clays containing cinnabar). Euphotides and other serpentine-rocks are associated with these.

7. Eocene sandstones, occurring in lenticular and wedge-like masses, occasionally dovetailed with the overlying limestones.

6. Nummulitic limestone, interbedded with red and grey clays.

5. Argillaceous shales and red and grey fucoidal limestones, alternating with reddish calcareous breccias (containing fishes' teeth) and manganiferous shales. Probably in part Lower Eocene and in part Upper Cretaceous.

4. Senonian limestones and shales, with manganiferous beds.

3. Upper Liassic shales of various colours, underlain by

2. Shales and cinnabar-bearing limestones, also belonging to the Upper Lias.

1. Middle and Lower Liassic limestones, passing in places into gypsum-beds.

Exploration-work has shown the chief cinnabar-deposit so far known below Monte Amiata to occur in a " chaotic mass " beneath a trachytic sill, 165 feet thick, which is itself overlain at Lame by a lacustrine deposit. Speaking generally, both the Eocene and Mesozoic formations hereabouts are ridged up into anticlines. The metalliferous (cinnabar-bearing) clays and sands occur also in the lake-bed above the trachyte, which itself has undergone dislocation, fissuring and slipping. It seems probable that all these cinnabar-bearing beds are the secondary stage of pre-existing deposits, and that the primary origin of them is connected with the emanations of sulphuretted hydrogen (*putrizze*) and the sulphureous thermal springs so common in this portion of the Monte-Amiata massif. The author thinks that more important cinnabar-deposits than those yet touched will be found in the Upper Liassic rocks of the district.

(2) *Das Zinnobervorkommen am Monte Amiata, Toskana.* *By* VINCENZ SPIRER. *Zeitschrift für praktische Geologie*, 1902, *vol. x., pages* 297-299.

In 1897, the author explained the results to which a prolonged study of these deposits had led him, in so far as their genesis is concerned. An acid solution of sulphates of mercury, iron, and other metals invaded the argillaceous limestones, whether of Liassic or Eocene age, and the subsequent chemical reactions, especially if hydrogen sulphide were present, favoured the formation of compounds of sulphur with calcium and the alkalies, causing the mercury to be precipitated from the now neutral solution in the form of red, crystalline cinnabar. This mineral variety can be originated only in the presence of highly sulphidic alkalies or alkaline earths in neutral or alkaline solutions, otherwise the sulphide of mercury appears as a black amorphous precipitate.

The argillaceous constituents of the limestone formed a sort of protective crust around the cinnabar, shielding it from re-solution, and in the hollows of the limestone, pyrites and selenite were also deposited in company with it. At a subsequent period, waters charged with carbonic acid enlarged the old and formed new hollows in the limestone, and the cinnabar was redeposited, this time in association with calcspar; or, in those cases where the neighbouring rocks are of a porous character (trachytes, sandstones, etc.) the cinnabar was actually carried away by the circulating waters. It occurs also as an impregnation in the most recent travertines.

The author's views have been confirmed by the researches of Mr. B. Lotti, one of the principal officers of the Italian Geological Survey, and by the observations of Mr. F. Amman, who manages the newly-opened mine of Abbadia San Salvatore.

The point that remains to be determined is the source of the sulphuric acid metalliferous solutions. They are evidently associated with the eruptive magma which formed the diabases and serpentines of the district.

(3) *Il Monte Amiata.* By A. VERRI. *Bollettino della Società geologica Italiana*, 1903, *vol. xxii., pages* 9-39, *with* 1 *text-figure and plate II.*

After a description of the Mesozoic and Tertiary sedimentaries which overspread the country around the central mountain-mass, the author devotes some pages to the volcanic rocks (largely rhyolites and trachytes) of which Monte Amiata itself is built up. He takes the opportunity of describing also the neighbouring volcanic mass of Radicofani, the mere remnant of a great basaltic eruption. Both that cone and Monte Amiata stood up possibly as islands in the later Pliocene sea, the volcanic phenomena dating perhaps precisely from that period. The moribund phase of vulcanicity is represented in the neighbourhood by numerous thermal springs, some of which are sulphureous, others ferruginous and highly charged with carbonic acid.

The cinnabar appears to be impartially distributed among the Mesozoic sedimentaries (Cornacchino mine); the Eocene marls, etc. (Siele and Solforate mines); the Eocene sandstones and Nummulitic limestones (Montebuono and Cortevecchia mines); the Pliocene sedimentaries (Saturina mine); and even among the trachytes and the overlying lacustrine deposits. It was worked by the ancient Etruscans, who used the ore simply as colouring-matter, and again in mediæval times (from 1200 to 1300). Wars and plagues decimated the country, and the mineral-industry was not revived there until 1846. In 1901, the mines of Abbadia, Cornacchino, Siele, Solforate, etc., were being actively worked, and the total output amounted to 278 tons of metallic mercury, the average yield of metal from the ore being 7·74 parts per thousand. Native mercury sometimes occurs in "drops" with the cinnabar, and the other associates are iron-pyrites, gypsum (both amorphous and crystalline), calcite, and rarely quartz. At Selvena, stibine also occurs, while at San Martino cinnabar is found in an antimony-mine. The richest ore occurs in pipes (or pockets) of clay or sand among marly and other limestones.

The author summarizes the various opinions expressed by a succession of writers, from 1850 to 1903, as to the origin of the cinnabar-deposits. With differences as to detail, all are agreed that the genesis of these deposits is undoubtedly connected, directly or indirectly, with the volcanic phenomena of the neighbourhood. L. L. B.

THE BOGHEAD OF RESIUTTA, ITALY.

Resiutta: Cenni su quello Schisto bituminoso (Boghead). ANON. [16 *pp. pamphlet published by G. Smerzi e C., Venice*, 1901.]

The bituminous shale of Resiutta occurs about 3,300 feet above sea-level, and 2,600 feet above the Pontebbana railway-line, among (perhaps stratigraphically below?) the Triassic strata which are the predominant sedimentary formations of the Tagliamento river-basin. An analysis shows that it contains 47·47 per cent. of volatile matter (and water), 14·2 per cent. of fixed carbon, and 38·33 per cent. of ash. The percentage of sulphur is stated as 3·847, and of phosphoric anhydride in the ash 0·84. Distilled at high temperatures, the "boghead" produces a gas of exceptional illuminating-power. At lower temperatures it gives rise to a whole series of coal-tar products, and heavy and light oils. The specific gravity of the mineral is 3·12.

Experiments made by the City-of-Venice Gas Company showed that the distillation of the Resiutta boghead furnishes a gas which may be used either by itself as an illuminant, or for enriching or carburetting ordinary

gas: in the latter case the addition of a very small percentage of it produces a relatively considerable effect. The coke obtained from this bog-head is of no value as a fuel, but if ground to powder it is available for bleaching and disinfecting purposes. L. L. B.

LIGNITES OF THE VICENTINO, NORTHERN ITALY.

Di alcuni Giacimenti lignitiferi del Vicentino. By T. TARAMELLI. *Giornale di Geologia pratica*, 1903, *vol. i., pages* 141-144.

The author agrees with Dr. Dal Lago in considering that the Eocene lignites which crop out at several localities in the province of Vicenza are not derived from peat, but from vegetable débris (trunks, branches and leaves) drifted into and accumulated in the lakes and estuaries of the early Tertiary period. He mentions, by the way, the bituminous lignites of Zovencedo and Monteviale, which yield but a small output and that of poor quality. These are of Oligocene age.

The most important deposits of the province lie among the hills through which the Agno, the Chiampo, the Alpone, the Illasi, and their affluents have cut their way. In the valley of the first-named a basalt-flow may be seen underlying the oldest Eocene, while elsewhere the Tertiary sedimentaries are traversed by intrusive dykes of later eruption. The oldest lignite-deposit in the region known to the author, that of Monte Pulli, rests upon *Alveolina*-limestones with intercalations of shelly bituminous marl. The mineral contains much sulphur, was first worked in 1841, and is once more the object of mining operations, although the deposit is not such as to admit of working on a very extensive scale.

Two beds of lignite have been traced in the neighbourhood of Castelvecchio, west of the Val d'Agno. Exploration-work in the commune of Cerealto has revealed other deposits, too thin to repay systematic working. The author visited a great many exposures of lignite, some of which were worked for a time, and then abandoned, and he concludes that, on the whole, the Monte Pulli deposits alone show promise of continuous remunerative working. The most recent statistics as to the annual output of lignites and bituminous schists in the province of Vicenza fix the amount at about 11,000 tons.

L. L. B.

THE ORE-DEPOSITS OF BROSSO AND TRAVERSELLA, PIEDMONT.

Die Erzlagerstätten von Brosso und Traversella in Piedmont. By V. NOVARESE. *Zeitschrift für praktische Geologie*, 1902, *vol. x., pages* 179-187, *with* 4 *figures in the text.*

Both these localities are in the district of Ivrea, on the margin of the Alps, near the point where the Val d'Aosta opens out into the great plain of the Po. The hills consist principally of mica-schists, in which are included numerous masses of eclogite and (though more seldom) extensive intercalations of crystalline limestones and dolomites. Between Brosso and Traversella, at the watershed which divides the Val d'Aosta from the Chiusella valley, a biotite-hornblende-diorite mass is intruded among the mica-schists, sending out numerous apophyses in the shape of small dykes or veins. In that neighbourhood the greatly disturbed mica-schists are traversed by numerous fissures striking north-westward and dipping regularly northward. These fissures are undoubtedly connected with the genesis of the ore-deposits.

The diorites have altered the limestones by contact-metamorphism, and in parts there has been a metasomatic replacement of limestone by oxides and sulphides of iron, and, secondarily, copper-pyrites. The phenomena are comparable with those observed in the ore-deposits of the Banate, and in the contact-rocks of the Christiania district.

The author then considers the ore-occurrences in detail, dividing them into three groups, the first of which comprises the magnetic iron-ores of the Bersella valley. Mining operations began here as long ago as 1487, but the industry is now at an end, and the old workings are difficult of access. Nevertheless, attempts are being made to revive mining here. In the upper part of the valley are the pure magnetites of Montajeu and Gias del Gallo (5,300 to 5,900 feet above sea-level): the ore is associated with more or less serpentinized olivine, and occurs in the form of intercalated beds among the limestones (which are in places highly silicified). In the lower part of the valley, are the iron- and copper-ore deposits of Traversella properly so-called. They are very near to the great diorite-mass, and with the magnetite are associated numerous metallic sulphides and a host of accessory ores and minerals. But the only ores that occur in payable quantity are the ubiquitous magnetite and copper-pyrites.

The second group comprises the specular iron-ore and pyrites of Brosso. From the point of view of facilities of transport these mines are much better situated than those of the Bersella valley. Working has been carried on in the Brosso mines without interruption, from the time of the ancient Romans down to our own day. The ore-bodies are in the form of banks or beds, conformably intercalated among crystalline limestones which strike westward, and dip 30 to 40 degrees southward. The thickness of the ore, however, varies considerably, from nothing to 200 feet or so. Evidently both the specular iron and the pyrites were deposited contemporaneously, and, although they are not found intimately intergrown, intrusions of the one are frequently observed in the other. The pyrites is very pure, and shows no trace of copper. Magnetic pyrites and magnetite occur, but are not worked hereabouts. The average annual production of the Brosso mines amounts to 25,000 tons of ore.

In the third group, the author ranges the metalliferous veins, which occur as infillings of the fissures mentioned in a previous paragraph. The ores in these are invariably sulphidic, and occasionally auriferous. Such fissure-deposits are common both to Brosso and Traversella, and the gangue consists of quartz and spathose iron-ore.

There is no doubt whatever that the genesis of all the ores described in this memoir is connected with the eruption of the diorite, which took place (in all probability) subsequent to the Oligocene folding of the Alps. Metalliferous vapours and solutions arose directly or indirectly from the eruptive mass, and made their way through the limestone-rocks. These were in part dissolved and leached out, and the ores and gangue-minerals were laid down in their place. L. L. B.

THE CUPRIFEROUS DEPOSITS OF BENA DE PADRU, SARDINIA.

Il Crisocolla e la Vanadinite nella Miniera Cuprifera di Bena (de) Padru presso Oziери. By DOMENICO LOVISATO. *Atti della Real Accademia dei Lincei*, 1903, *series* 5, *Rendiconti*, *vol. xii.*, *pages* 81-87.

A few years ago, some curious outcrops of copper-ore were discovered at Bena de Padru, on the slopes of Monte Tramento, about a third of a

mile distant from the high road, which runs from the ancient and wealthy borough of Ozieri to the railway-station of Fraigas. The ores occur in the belt of clay-slates, which alternate with the calc-schists overlying the granulite, the last-named being the basement-rock of the district. The discovery was made in the course of prospecting for plumbiferous veins, which, however, in Sardinia generally become barren as they enter the granulite: the copper-ores, on the other hand, are found near the contact with that rock. The exploration-work so far accomplished has revealed three separate "veins," consisting of strings of lenticles, largely of chrysocolla (hydrated silicate of copper) with quartz and calcite. Nearer the outcrop, the chrysocolla is almost entirely replaced by carbonates, such as malachite, azurite and cerussite. Deeper down chalcopyrite occurs in masses, traversed by thin veinlets of chrysocolla and quartz. Evidently we are dealing here with a deposit originally of sulphidic ores, decomposed by various agencies into oxides, sulphates, etc. The chrysocolla is generally amorphous, compact, varying in colour from turquoise-blue to green and bluish-white, and encrusts the schistose rocks. Chemical analysis shows it to contain about 40 per cent. of cupric oxide. In the centre of some of the lenticles is a reddish chocolate-coloured mineral, presenting the appearance of limonite: on analysis it is found to contain 34·5 per cent. of cupric oxide and 38 per cent. of iron oxides. It has been said that the purest copper-ores in these deposits contain as much as 67·7 per cent. of metallic copper. Near the contact with the granulite and in the granulite itself are small cubes and lumps of galena, also a vein of blende, 4 inches thick. Copper-ores are known to occur at other localities in Sardinia, but not in payable quantity, or at any rate in such conditions as to make working profitable. Whether the deposit at Bena de Padru is likely to prove of industrial importance, is a question which the author apparently leaves unanswered; but he hints at the difficulty of treating such a mixture of ores as that described. Vanadinite (chlorovanadate of lead) a rare mineral, and new to Sardinia, has been found in the same locality. L. L. B.

MANGANESE-ORES IN SARDINIA.

Dati analitici su alcuni Campioni di Manganese di Sardegna. *By* C. RIMATORI. *Atti della Reale Accademia dei Lincei, Rendiconti*, 1901, *series* 5, *vol. x.*, *pages* 226-232.

The author points out that, although the importance and the wealth of the ore-deposits which the island of Sardinia can boast are well understood by his countrymen and by foreigners alike, but little has been done hitherto in the way of exact chemical analysis of the mineral products. He believes that new mineral species will be found to exist among the lead-, zinc- and silver-ore deposits of that favoured island. For the present, he confines himself to a study of the manganiferous ores. Of these he describes eight specimens, obtained respectively from Padria, district of Alghero (2), from the pale pink trachytes near Punta Giordano, from the limestone of Pozzomaggiore, from the volcanic rocks between Ploaghe and Chiaromonti, from the andesitic trachytes near Siliqua, from the deposits between Bosa and Montresta and those on the islet of St. Peter, between Capo Rosso and Capo Becco.

As a whole, the ores are varieties of pyrolusite, but that from Bosa-Montresta contains 20·68 per cent. of lead monoxide, and reminds one of the

wad of Baden recorded by Prof. Dana. Those from Padria and the Punta Giordano may be considered as varieties of psilomelane. Sometimes the manganese-ore occurs in the form of nodules and small concretions (Padria, Pozzomaggiore, etc.), elsewhere it is more or less intimately intermingled with the mass of calcareous or trachytic rock, or trachytic and andesitic tuff. Complete chemical analyses are tabulated by the author.

L. L. B.

PETROLEUM-DEPOSITS OF TRAMUTOLA, ITALY.

Il Petrolio nel Territorio di Tramutola (Potenza). By C. CREMA. *Bollettino della Società geologica Italiana*, 1902, *vol. xxi., pages xxxvi.-xxxviii.*

The author was recently deputed by the Department of Mines to report on the undoubted occurrence of petroleum in the district of Tramutola, Potenza. The oil-bearing area occupies at most 2 square miles, in the northern portion of the narrow valley, through which a streamlet called the Cávolo runs, to the west of Tramutola. Leaving out of account alluvial deposits (Quaternary) the strata are, in descending order:—Eocene clay-slates, marly limestones and sandstones; Cretaceous massive grey limestones; Upper Triassic dolomites (Hauptdolomit); and Middle Triassic siliceous schists and limestones. The bottom of the valley is almost entirely excavated in Eocene rocks; and in a little tributary glen, a rather brackish spring wells out, at the junction of the Eocene and the Triassic limestone, yielding continuously small quantities of petroleum with the water, and occasionally bubbles of gas. The oil is of a dark-brown colour, and has a specific gravity of 0·9. Another similar occurrence is cited farther north, also at the junction of Eocene and Trias; and a few shallow borings put down through the Quaternary deposits which overlie the Eocene in the little valley of Pietragrattata have also struck oil.

The author is disposed to infer that the more porous strata of the Eocene group in this district (the marls, and especially the sandstones) constitute the oil-reservoir: they are more or less regularly folded into anticlines, and alternate with impermeable strata. From the data at present available he concludes that there is little hope of this oil-field proving the site of a remunerative industry, but adds that this point can only be definitely settled by putting down a deep boring. L. L. B.

IRON-ORES IN SOUTHERN PORTUGAL.

Eisenerze im südlichen Portugal. By — WERNEKE. *Zeitschrift für praktische Geologie*, 1902, *vol. x., pages* 151-152, *with* 4 *figures in the text.*

A German company is engaged in working the deposits at Villa de Frades in the district of Beja, province of Alemtejo. Prospecting has shown that the present area of mining operations in that region is susceptible of wide extension.

All the ores appear to be associated with the contact-zone of the greenstones, which are either interbedded as sills with the Archæan rocks or traverse these in the form of dykes. The ores occur sometimes in immediate contact with the greenstones, and sometimes in contiguous, apparently "contact-metamorphosed" strata of a slaty or calcareous character. The ore-bodies assume generally the shape of irregular lenticles.

In the Pichoto mine, the ore is a crystalline-granular magnetite with about 56 per cent. of iron, 7 to 8 per cent. of lime, 3 to 4 per cent. of silica, and 0·012 per cent. of phosphorus. At the outcrop the ore is changed to martite. On account of its excellent quality, it is much prized by the managers of several of the Rhenish-Westphalian blast-furnaces. The country-rock on the foot-wall side is greenstone partly very tough and compact, partly decomposed and shaly. The hanging-wall is limestone of a curiously granular structure, evidently much corroded by contact-metamorphic changes.

It appears evident that when the greenstones were erupted, aqueous vapours under high pressure were evolved from the eruptive magma, and, carrying along with them iron in solution from that magma, impregnated the neighbouring rocks. Such, at least, is the author's view of the genesis of the above-described ores. L. L. B.

PETROLEUM IN RUMANIA.

(1) *Sopra i Giacimenti petroliferi della Zona neogenica della Rumenia.* *By* G. DE ANGELIS D'OSSAT. *Giornale di Geologia pratica*, 1903, *vol. i., pages* 69-77; *and*

(2) *Recherches sur la Composition chimique des pétroles roumains.* *By* P. PONI. *Annales Scientifiques de l'Université de Jassy*, 1903, *vol. ii., pages* 65-80.

After pointing out that the petroleum-deposits of Rumania occur in three different formations:—(1) Cretaceous, as in the districts of Prahova and Dimbovitza; (2) older Tertiary; and (3) Neogene, in the sub-Carpathian region, the first author states that his attention was particularly directed to those of the third or latest series, and these are farthest away from the main Carpathian axis. The strata are Miocene and Pliocene marls, sands and conglomerates, with frequently-intercalated beds of gypsum and rock-salt. He sought in vain for fossils, and noted that the beds are generally much disturbed. He stoutly opposes, as regards that particular formation, the conventional hypothesis (true elsewhere in a vast number of cases) that the natural oil is to be looked for only below the anticlines. Nor does he regard that explanation as satisfactory which represents the petroleum-bearing beds as alternating with impermeable strata, and forming the remnant of a partly eroded anticline. His view is that in the Rumanian Neogene belt, oil should be sought for on exactly the same stratigraphical principles as water-bearing beds are sought for. It is true that the oil is lighter and flows therefore more easily, but he reminds us that in nature it is invariably accompanied by water.

With regard to the genesis of petroleum, although he favours on the whole the views of those who regard it as of organic origin, he points out that in some cases it may have been derived from some of the processes excogitated by those who uphold the volcanic theory.

The second author gives the continued results of his investigation into the composition of Rumanian petroleum, carried out largely by means of fractional distillation. He had already shown that the Colibasi oil contains tetramethylmethane, butane, propane and ethane. He proceeds to show that it also contains trimethylmethane (as does the Pennsylvanian and Ohio petroleum), secondary hexanes, benzene, tolulene, metaxylene (much more abundantly than the other aromatic carbides), mesitylene, etc.

L. L. B.

DIAMONDS IN THE URALS, RUSSIA.

Sur les Gisements de Diamants dans l'Oural. By W. MAMONTOW. *Bulletin de la Société Impériale des Naturalistes de Moscou*, 1902, *No.* 3, *page* 328.

The fortunate circumstance that, in the summer of 1899, the author was enabled to enrich the collection of the University of Moscow with the first Russian diamond possessed by it, is made a peg whereon to hang a compilation of the literature of the Ural diamonds. In the Northern Urals none of those precious stones have been discovered as yet, but no less than 16 diamantiferous deposits are dotted along the flanks, both eastern and western, of the Central and Southern Urals, and 222 diamond-crystals (or more) have been obtained there within the last 73 years. Generally they weigh less than a carat.

The diamond obtained by the author was a macled crystal, of a somewhat lenticular shape, weighing 1·107 carat, and was found by a peasant in the gold-bearing sands of the Polozhikha streamlet, in the neighbourhood of the village of Koltashi, domain of Neviansk, Urals. Since then, four more diamonds have been found in the same deposit. L. L. B.

THE MANGANESE-ORES OF YEKATERINOSLAV, SOUTHERN RUSSIA.

Die Manganerzlager in den Tertiären Ablagerungen des Gouvernements Jekaterinoslav. By N. SOKOLOV. *Mémoires du Comité géologique, St. Pétersbourg*, 1901, *vol. xviii., No.* 2, 80 *pages, with figures in the text, and* 2 *plates.*

These ore-deposits, which are now the object of active mining operations, occur near the south-western border of the Government of Yekaterinoslav, east and west of the great grain-trading centre of Nikopol on the Dnieper. On the west, the ore-deposits cover an area of about 50,000 acres, in the upper basin of the Chertomlyk, a small affluent of the Dnieper. The ore consists of irregular nodular concretions of pyrolusite, of varying internal structure (vesicular, concentric, crystalline, etc.), which are sometimes dispersed without any sort of order through a black loamy bed, and sometimes are aggregated into a regular stratum at the base of the deposit. The ore-bearing bed rarely exceeds 5 feet, though occasionally it reaches 7 and even 10 feet, in thickness. Its floor is an apple-green siliceous clay, bearing many impressions and casts of Oligocene mollusca. The roof is usually a greenish-grey plastic clay, unfossiliferous, but evidently to be grouped with the overlying, abundantly fossiliferous, Sarmatic clays.

The ridge of old crystalline rocks of the Balka Malaja Kamenka cuts off the mining area just described, from the very similar manganese-ore deposits that lie east of Nikopol. They too occur as nodular masses and bands of pyrolusite among Oligocene loams and clays, but here they rest immediately upon the more-or-less weathered granite and gneiss. In places the overlying Sarmatic beds have been denuded away, and the deposits are mantled by sub-recent freshwater silts and æolian loess. At Goredistshe and Krasnogrigoryevka, the base of the ore-deposit is formed by a stratum of pyrolusite-nodules, about the size of hazel-nuts, and varying in thickness from 8 to 30 inches. East of the Tomakovka river is still another ore-field, covering about 12,500 acres: very little exploration-work has been done on it so far.

Five manganese-mines altogether are at work in this region, with an estimated annual output of 85,000 tons of ore. Although certain other manganese-ore-deposits, on the Ingulez river below Krivòi Rog, are of

no industrial importance, they are important as showing that there is still a possibility of finding other workable deposits in the vast area that lies between the two rivers Ingulez and Bazaluk.

The author describes briefly some of the mollusca characteristic of the beds in which the manganese-ores occur. In the main, they are badly preserved, and the casts often consist largely of manganese. On the other hand, well-preserved sharks' teeth of different species are abundant, and the evidence which they afford has induced observers to assign the ore-deposits to the Middle Oligocene period. The author reserves, however, his final opinion on that point, until he shall have had time to study closely and work out thoroughly the available material.

He describes in some detail the petrographical and chemical characters of the ores, and it may be noted that in the western district (Pokrovskoye, etc.) they contain from 43 to 53 per cent. of metallic manganese, while in the eastern (Gorodistshe, Krasnogrigoryevka) they contain as much as 51 to 56 per cent. of the metal. The proportions of sulphur are infinitesimal, and those of phosphorus vary from 0·0175 to 0·36 per cent. The factor which mainly affects the quality of these ores is the varying amount of silica present; this, again, depends on the number of quartz-grains mechanically embedded in the ore. These pyrolusite-nodules of Yekaterinoslav recall vividly, both in outward appearance and in internal structure, the nodules dredged from the ocean-bed in the course of the deep-sea explorations of the "Challenger" and the "Albatross"; it is true, however, that the deep-sea nodules contain more iron and less manganese. In point of fact, the lithological and palæontological evidence taken together shows that the Yekaterinoslav deposits were formed in shallow water, not very far from a coast line. The author reconstructs in imagination the Oligocene geography of Southern Russia, and discusses at great length the possible origin of the manganese. He seems to think that it may have been derived from marine plants, peculiar to the Oligocene seas of Southern Russia and Transcaucasia, which had the power of elaborating or at least concentrating manganese compounds within themselves.

L. L. B.

THE HÆMATITE-DEPOSITS OF THE POKROVSKAIA ESTATE, SOUTHERN RUSSIA.

Sur le Gisement de Minerai de Fer dans le Domaine Pokrovskaia, Propriété du Grand Duc Michel Nikolaieritch. By N. Sokolov. *Bulletin du Comité géologique, St. Pétersbourg*, 1900, *vol. xix., pages* 407-421, *and plates VII.-VIII.* (*map and section*).

The Pokrovskaia estate, the property of the Grand Duke Michael Nikolaievich, is situated at the south-western extremity of the Government of Yekaterinoslav, at the confluence of the Bazaluk with the Dnieper. The brown hæmatite occurs in fairly large masses, among mottled clays of a vivid red, pink, violet, and lilac colour. The "nests" of ore attain a maximum thickness of 3½ feet: analyses have shown that the hæmatite contains between 40 and 50 per cent., sometimes even more, of metallic iron, mere traces of sulphur, and very small proportions of phosphorus (the percentage of phosphorus pentoxide varying from 0·09 to 0·15). Some samples contain chromium. The ore-deposits cover an area of about 18,000 acres; the mottled clays are overlain by the Oligocene sands and clays containing manganese-ores, and they rest upon ancient crystalline rocks. Among

these are granites, gneisses, diorites, amphibolites, chlorite-schists, talc-schists and quartzites seen along the banks of the Chertomlyk and the Solenaia, which streams form in part the boundaries of the estate. Exploration-work has gone down to a depth of 82 feet below the surface (at the Nijni Perevitzkaia farmstead) without touching the bottom of the hæmatitic clays. The projected railway from Nikopol to Krivòi Rog will much facilitate the working of these deposits. L. L. B.

THE IRON-ORES OF MOUNT MAGNITNAIA, RUSSIA.

Le Mont Magnitnaia et ses Alentours. By J. MOROZEWICZ. *Mémoires du Comité géologique, St. Pétersbourg*, 1901, *vol. xviii., No.* 1, 106 *pages, with figures in the text*, 6 *plates and* 1 *geological map.*

Mount Magnitnaia rises to the height of 1,892 feet above sea-level, on the eastern slope of the Southern Urals, 149 miles distant from Miask, the nearest railway-station. In reality it is a massif consisting of several hills rather than one, and it dominates a hilly plateau which passes eastward into the Kirghiz steppes. It covers a surface of 9¼ square miles, and the minimum amount of iron-ore which it contains is estimated by the author at upwards of 48,000,000 tons.

He gives first of all a petrographical description of the rocks of the massif, pointing out that these are essentially of eruptive origin. They consist of granites, felsites, diorites, syenites, porphyries, diabases, and a rock which he names "atachite," from its occurrence on the crest of Mount Atach, the highest summit of the Magnitnaia massif. This rock is "briefly" defined as a cordierite-sillimanite vitro-orthophyre.

To the crystalline rocks of secondary formation belong the granatite- or garnet-rocks, and the associated magnetite, martite and hæmatite-deposits. The ore-deposits, although not strictly continuous, cover an area of about 500 acres: there are frequent alternations of barren rock (decomposed garnet-epidote rock and kaolin). Magnetite is the predominant ore: it occurs occasionally in black compact masses that look as if fused. This compact variety often contains as much as a third of its volume of quartz, while the non-compact variety frequently consists for about one half of garnet. In many places the magnetite is partly altered into martite. On an average, the ore consists of: magnetite, 25 to 50 per cent.; martite, 32 to 58; quartz, 10 to 12; garnet, 2 to 18; kaolin, *nil* to 5. Hæmatite occurs both as an oxidation-product of magnetite, and independently in the form of lamellar crystals in the garnet-rock. In mass it is frequently porous, and is associated with quartz and clay, as well as pyrites and gypsum. The average percentage of its constituents, deduced from these analyses, is as follows:—hæmatite, 67 to 98; quartz, *nil* to 20; kaolin, 2 to 13; and pyrites, *nil* to 3.

In the fissures of the altered argillaceous and garnet-bearing rocks a concretionary ore occurs, which is found to contain 10 per cent. of pyrolusite, 80 per cent. of limonite, and 10 per cent. of clay.

The general character of the iron-ore deposits is summarized as follows:—They occur in altered garnet-epidote and kaolin-rocks, which rest upon more or less decomposed augite-felspar rocks. The greater the alteration that the garnet-bearing rock has undergone, the richer as a rule is the deposit. The ore alternates very irregularly with the country-rock, amid which it

occurs in masses, nests, or beds. The deposits are generally to be found on the slopes or at the base of the Magnitnaia massif. To judge from the borings, the ore-deposits show no particular change down to a depth of 250 feet. Impregnations of pyrites begin to be observed at about 50 or 60 feet from bank, and nearer the surface gypsum takes the place of pyrites.

The various theories by which it has been sought to account for the origin of the Magnitnaia ores are discussed, and it may be observed in passing that the analogy of these ores to the famous deposits of Blagodat and Vysókaya has been generally noted. The author concludes in favour of a gradual hydro-chemical metamorphosis of the eruptive augite-felspar rocks by the intermediary of the garnet-rock. It may be observed that the eruptives themselves contain a considerable amount of primary magnetite, which was probably one of the first constituents to crystallize out of the igneous magma; so much indeed, that one-tenth of their weight could have been transformed into ore. It is further shown that, in the Urals at least, augite very commonly decomposes into chlorite and garnet, setting free a certain amount of iron-oxide. Garnet itself, decomposed in presence of water and carbonic acid, may give up as much as 30 per cent. of free iron-oxide. (It will be remembered that in certain European localities pseudomorphs of red and brown hæmatite after garnet are known to occur; and that garnet is a frequent associate of metalliferous deposits.) Quartz and calcite represent the last phase of the cycle of hydro-chemical phenomena, which resulted in the separation and accumulation of a considerable quantity of free iron oxides, by the agency of garnet and epidote.

The few outliers of sedimentary rocks that denudation has spared in this neighbourhood are Lower Carboniferous and Middle Devonian limestones.

L. L. B.

THE IRON-ORES OF TROÏTSK, NORTHERN URALS.

Sur le Minerai de Fer de Troïtsk (Oural du Nord). *By* L. DUPARC *and* L. MRAZEC. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences*, 1903, *vol. cxxxvi., pages* 1409-1411.

Troïtsk is situated on the left bank of the Kosva river, in the Government of Perm. Here "granite-porphyry" crops out amid the Lower Devonian strata, and with it is associated the occurrence of iron-ores. A band of magnetite mixed with hæmatite, from 3 to 56 feet in thickness, is observed wherever the igneous rock appears, to have developed contact-metamorphism in the sedimentaries of earlier age than the Devonian.

The Osamka mine is worked opencast at seven successive horizons. At the lowest level, bands of ore varying from 20 inches to 6½ feet in thickness are separated by thin partings of micaceous hornstones; they form here a very flat anticline, which at the succeeding higher levels becomes more and more accentuated, until it passes into a "contortion-fault." The total thickness of ore and partings in the anticline amounts to 56 feet, the whole dipping gently northward below the porphyry: while near the southern end of the mine ore-bands and partings abut against a wall of porphyry. The structure of the ore varies: sometimes it is absolutely compact, in other cases the magnetite-crystals form a sort of meshwork amid the interstices of which white mica has crystallized out; in yet others, the magnetite in the form of isolated crystals is abundantly disseminated throughout a micaceous and lamellar groundmass. It is perfectly evident that

the magnetite is the result of metamorphism, induced by the "porphyry" or granitic magma, in the strata which are now hornstones. That this took place before Devonian times is proved by the fact that pebbles of the "granite-porphyry" occur in the Lower Devonian conglomerates. The somewhat complicated relations of the rocks are explained by earth-movements, both pre-Devonian and post-Devonian. L. L. B.

THE TURGITE-ORES OF RUSSIA.

Die Turjiterze Russlands. *By* PROF. J. SAMOJLOFF. *Zeitschrift für praktische Geologie*, 1903, *vol. xi., pages* 301-302.

Turgite, a hydrated oxide of iron, has often been confounded with hæmatite and limonite, and there are still some mineralogists who refuse to regard it as a distinct mineral species. Its chemical formula, as given by the author, is $2\,Fe_2O_3, H_2O$, and he has described elsewhere important deposits of it in the Southern Ural (Bakal mines, Zlatóust). The mineral was first identified by Hermann in 1845 from the Turginsk mine, Bogoslovsk district, Northern Ural.

Turgite-ores have been recently discovered at several localities in Central Russia, and a good example of their composition is given by the chemical analysis of one from Vladimirovka, in the Government of Tula. This shows the following percentages: iron sesquioxide, 87·93; silica, 2·12; alumina, 1·6; phosphorus pentoxide, 1·57; and combined water, 6·52.

Close examination of iron-ore deposits in various parts of the world is likely to prove, in the author's opinion, that turgite is of far more widespread occurrence than is generally imagined. L. L. B.

GLAUBER'S SALT-DEPOSIT IN TRANSCASPIA.

Glaubersalzschichten im Adschidarja. *By* DR. CARL OCHSENIUS. *Zeitschrift für praktische Geologie*, 1903, *vol. xi., page* 33.

The report recently published by the Russian Ministry of Agriculture, on the results of a Government expedition to the Gulf of Achidarya, on the eastern coast of the Caspian Sea, announces that a deposit of Glauber's salts, some 6½ feet thick, occurs on the sea-bottom there, and increases annually in thickness by about two-fifths of an inch. Similar occurrences are reported from several of the shrunken lakes of the Aralo-Caspian depression, and these are all deemed of high importance from the point of view of Russian chemical industry. Indeed, it is asserted that they may enable Russia in time to become the world's provider for soda.

Meanwhile, it may be observed that the neighbourhood of the Achidarya is unmitigated desert, that the deposit itself lies under water, and that the facilities of transport are not particularly favourable. L. L. B.

PLATINUM IN THE NICKEL-ORES OF NORWAY.

Platingehalt im Norwegischen Nickelerz. *By* PROF. J. H. L. VOGT. *Zeitschrift für praktische Geologie*, 1902, *vol. x., pages* 258-260.

In view of the fact that the Norwegian deposits of nickel-ore and magnetic pyrites are very similar, both geologically and mineralogically to

those of Sudbury in Canada and Klefva in Sweden, there was an *a-priori* probability that in Norway too the nickel-ores would be found to contain platinum. In order to settle this point, the author made careful chemical analyses of specimens from Ringerike and Evje. The former yielded, as well as platinum, minute proportions of osmium, iridium and gold, the latter traces only of platinum and gold. A comparison of the analyses of the Norwegian, with those of the Canadian ores, shows that the ratios of percentages, between silver and nickel and gold and platinum respectively, are identical in the ores from either side of the Atlantic. Moreover, it is now possible to state, that whenever nickel-ores have been examined for platinum and gold, they have invariably been found to contain both these precious metals. Whence the author concludes that the gabbro-magma from which the nickeliferous magnetic pyrites-deposits were originally separated out by differentiation must have contained gold, platinum and silver, and that the mineralogical composition of this magma must have been practically the same in Europe as in America.

He lays stress on the point that platinum in the native state, occurring as it does chiefly in olivine-rocks and serpentines derived therefrom, is also the outcome of magmatic differentiation. On the other hand, platinum is either absent or present only in infinitesimally minute proportions, in such ore-deposits as were formed by hydrochemical processes. The reason probably is, that such processes did not develop a sufficiently high oxidizing or chlorinating power to dissolve the extremely refractory platinum-metals. It is easier to bring gold into solution than platinum, and thus while the latter is of more widespread occurrence in basic eruptive rocks, the former is correspondingly more abundant in "hydrochemical" ore-deposits. The occurrence of the above-mentioned precious metals in the Norwegian nickel-ores does not seem likely to prove industrially important. L. L. B.

COPPER-ORE DEPOSITS IN SERVIA.

Die Kupfererzlagerstätten von Rebelj und Wis in Serbien. *By* R. BECK *and* W. VON FIRCKS. *Zeitschrift für praktische Geologie*, 1901, *vol. ix.*, *pages* 321-323, *with* 3 *figures in the text.*

The deposits described in this paper occur in north-western Servia, south-west of Valjevo, in the river-basin of the Yablonica, one of the tributaries of the Kolubara. The cupriferous belt strikes north-west and south-east, and the ores are associated with masses of serpentine which appear to have thrust themselves among the Mesozoic sedimentaries on the northern slope of the Povljen mountain-range. So far, mining-operations have been confined to the deposits of Rebelj and Wis, in the neighbourhood of the village of Brezovica.

At Rebelj, the pale-grey, argillaceous, calcite-veined Triassic limestone is intruded into by an apparently-conformable sill of serpentine, 197 feet thick, the outcrop of which can be traced for about a third of a mile. The serpentine is highly decomposed, much slickensided, and very rich in magnetite. Amid it lie lenticular masses of ore, which may reach a maximum of 98 feet in length and 53 feet in thickness. Peripherally they consist of copper-pyrites with which iron-pyrites and serpentine are sparsely intermingled, and in that portion contain up to 15 per cent. of copper. They are poorer towards the centre, which consists largely of cubic crystals of iron-

pyrites, accompanied by copper-pyrites, calcite and serpentine: here the percentage of copper is generally less than 5. At the outcrop, the ore-bodies pass into a cavernous brown hæmatite, containing from 10 to 15 per cent. of copper (associated with it are fine acicular crystals of chalkotrichite, incrustations and crystals of azurite and malachite, and remnants of undecomposed copper-pyrites). It is to be observed that the serpentine at the outcrop, quite apart from the cupriferous ore-bodies, is often rich in brown hæmatite, which is doubtless derived from the decomposition of the magnetite in the serpentine.

At Wis, a mine buried in the primæval forest, the Triassic limestone is again broken through by a dyke-like mass of serpentine; but along one of the salbands a mass of diabasic thrust-breccia intervenes between the serpentine and the limestone. The ore consists of irregular lumps of copper-pyrites, mingled with but little iron-pyrites and serpentine: these lumps may weigh as much as a ton, they contain from 8 to 14 per cent. of copper, and occur always very near the junction with the breccia.

Similar cupriferous deposits are found along the same mountain-range at Rudanovci, Wuinovatz and Staninareka. They are all comparable genetically with the occurrence at Monte Catini, in Tuscany; with the difference that, in Servia, the concentration of the ore in its present form took place during the secondary, complete metamorphosis of the olivine-bearing mother-rock. L. L. B.

THE COAL-FIELD OF BELMEZ, SPAIN.

Memoria descriptiva de la Cuenca carbonifera de Belmez. By L. MALLADA. *Boletin de la Comisión del Mapa geológico de España*, 1902, *series* 2, *vol. vi., pages* 1-80, *with* 4 *text-figures, and plates I.-II.*

Only a small portion of this basin has been properly explored and mined in underground workings, and the author says that much work remains to be done before the field is properly developed. The seams are extremely irregular, much dislocated, and the measures are in most cases covered by a thick mantle of drift-deposits.

The exhaustive memoir under review is divided into three principal sections, the first of which deals with the general geology of the coal-basin, the second is a detailed description of the mines, and the third is devoted to industrial considerations.

The coal-basin forms a belt of about 37 miles in length and 1½ miles in mean breadth, extending from north-west to south-east, parallel to the Guadiato river, and occupying an area of some 56 square miles. The Coal-measures are flanked on either side by older strata, and by igneous rocks which are intrusive in the Coal-measures themselves as well as in the older strata. The last-named comprise Archæan crystalline schists, Cambrian slates, Silurian quartzites, Devonian slates, highly-fossiliferous limestones and grits. The igneous dykes, bosses, and sills are generally either quartz-porphyries or diabases, and they are of more frequent occurrence at the northern than at the southern extremity of the basin. About four-fifths of the basin is masked by red stony clays, and more or less conglomerated gravels of Quaternary age.

Within the basin, the following rock-groups are recognized: Carboniferous Limestone, sometimes jammed in by faults among the Coal-measures, barren Culm-measures (also termed by the author Lower Coal-measures), and the

Coal-measures proper. In no other district in Spain, or indeed in Europe, are Coal-measure conglomerates so extensively developed. Not only do they occur at the base, but are intercalated at various horizons with the shales and grits which accompany the coal. Another characteristic is the abundance of clay-ironstone. The coal varies in quality from anthracitic, dry, or semi-bituminous, to bituminous. Some of the last-named coals are very gassy, others not at all so. The variations in thickness of the seam are extreme, ranging from 131 feet in one place to a few inches in another. In fact, the definition "pockets" would be more properly applicable to the present condition of the deposits than the term "seams." Taken as a whole, the Coal-measures strike north-west and south-east, and dip south-westward, with local divergencies from these directions.

For the purpose of a detailed description the mines are divided into four groups: (1) from the northern boundary to the town of Belmez; (2) between Belmez and the Albardado stream; (3) between the Albardado and Espiel; and (4) between Espiel and La Ballesta. The highest seams are those nearest the Guadiato.

The history of mining industry in the basin dates back to 1790, and at the present day the field is practically parcelled out among six great companies. Tables of analyses of the various coals are given, the maximum and minimum percentages being as follows: carbon, 75 and 48·4; volatile matter, 43·2 and 13; ash, 12 and 2·6. The seams worked in the Terrible and Santa Elisa mines are especially suitable for gas and coke manufacture. Some of the coals are very tender, and make a lot of small coal.

The deepest shafts described are the Camondo, on the Santa Elisa property, which goes down to a depth of 875 feet; and the Canóvas, on the Cabeza de Vaca, 836 feet. The average wage, including workmen both above and below ground, is 2s. 8d. per day, and the cost of output per metric ton of coal varies between 7s. and 9s. 6d. In comparison with other coal-fields, such as that of the Asturias, the cost of pit-timber is excessive. Pine-timber (all but exclusively) is used, imported from Portugal or brought from Huelva and certain districts of the Sierra de Córdoba. The coal-tubs are generally built up in the mines themselves, the necessary iron or steel being imported from foreign countries direct, or brought from Córdoba.

The cost of pumping varies greatly from mine to mine, but that of ventilation and lighting is more generally uniform. Guibal, Ser and Mortier fans are used, and safety-lamps are very generally employed. In the mines of the Santa Ana group, however, and La Calera, fire-damp being present (when present at all) in extremely small quantities, it is thought safe to use naked lights.

The total output from 1861 to 1900 inclusive was close on 7,000,000 tons, of which 1,850,000 belong to the quinquennium 1896 to 1900. The author believes that a good deal more coal, immensely more, will be got from this basin in the future. In fact, given the proper plant and improved means of transport, the output within the next twenty years could be increased fivefold. L. L. B.

THE VALVERDE BORING, CIUDAD REAL, SPAIN.

Sondeo de Valverde (Ciudad Real). By CASIMIRO COELLO. *Boletin de la Comisión del Mapa geológico de España*, 1902, *series* 2, *vol. vi., pages* 253-256.

About the end of 1899, in the township of Valverdere, west of Ciudad Real, and very close to the Guadiana river, in sinking a well, rather sandy white

clays with carbonaceous patches were struck, at no great depth from the surface. This gave rise to the expectation that coal-bearing beds might be found at an easily accessible depth, and so a company was formed and a mining concession duly obtained. There was some justification for this, as the geological structure of the country is that of a wide basin, surrounded by a rim of Silurian rocks, and stretching between the western spurs of the Sierra de Alarcos and the eastern spurs of the Alcolea range, down to the Guadiana. Boring operations were commenced in the autumn of 1900, but were stopped at a depth of 112 feet, on account of the abundant inflow of water and the loose texture of the rocks bored through, which were continually falling in. The strata consisted of clays, marls and sands, some of which were carbonaceous and pyritous, with a remarkable plant-bed in which the leaves still retain some of their green coloration.

In the spring of 1901, operations were resumed some 90 feet west of the first spot, but the boring was stopped at a depth of 217 feet, on account of an accident to the apparatus. Then with a diamond-borer, an attempt was made nearer the centre of the basin, south of the first locality chosen, and a depth of 315 feet was reached (in grey grauwacke with ferruginous inclusions) but the expected coal-formation was not met with. As a matter of fact, after passing through Quaternary and Miocene strata the Silurian had been struck, thus showing that the Coal-measures are absent.

L. L. B.

THE ORIGIN OF THE PYRITES-DEPOSITS OF SOUTHERN SPAIN.

Ueber das Auftreten und die Entstehung der Südspanischen Kieslagerstätten. By Dr. F. Klockmann. *Zeitschrift für praktische Geologie*, 1902, *vol. x.*, *pages* 113-115.

The author publishes here the conclusions at which he has arrived, after seven years' renewed study on the spot, concerning the famous pyrites-deposits of the provinces of Huelva, Seville and Alemtejo.

In all cases, the ore-beds are intercalated conformably with the surrounding slates. The imaginary unconformities which have been recorded are the outcome of hasty or inaccurate observation. Moreover, the ore-beds are confined to the Culm-measures, the supposed intercalation of some of them among the Silurian strata being now disproved. With the ore-occurrences are associated eruptive sills—consisting of quartzose and quartzless porphyries, porphyrites and diabases; also amygdaloidal tuffs. The sills, too, are conformably intercalated among the Culm-measures.

After enumerating the reasons which forbid him from regarding the pyrites here as in any sense a vein-deposit, the author points out that only one explanation accounts satisfactorily for the origin of the ore—it is a concretionary segregation within a plastic clay-slate mud, saturated with the chemical elements of pyrites. It is very possible that this segregation was initiated and accompanied by precipitations of pyritic matter. The sills and tuffs, doubtless the outcome of submarine volcanic phenomena, were the "ore-bringers."

The author traces a genetic relationship between the Spanish pyrites-deposits and, among others, the blackband ironstones and sphærosiderites of the Coal-measures.

L. L. B

COPPER-ORES IN THE TRIAS OF MINORCA AND GRANADA, SPAIN.

Criaderos sedimentarios de Cobre en Menorca y en Granada. By R. S. Lozano. *Boletin de la Comisión del Mapa geológico de España*, 1902, *series* 2, *vol. vi.*, *pages* 233-244.

The author points out that a character common to nearly all the cupriferous deposits that are contemporaneous with the sedimentary rocks in which they occur, is the association of plant-remains around which the copper-minerals are more or less concentrated, or sometimes actually take the place of the plants by metasomatosis. Among such deposits are those of Mansfeld, of Bohemia and of Russia (Perm). It it true that others, although stratified, contain no demonstrably organic remains, such as those of the Caucasus, El Boleo and Rammelsberg. With the foregoing he is inclined to correlate the Spanish occurrences which he describes.

In various localities of the Island of Minorca, intercalated among the Lower Triassic sandstones, are cupriferous deposits, which have long been known, but do not appear to have attracted serious attention until quite lately. The best known district lies in the central region of the island, between Mercadal and Monte Toro. The copper-ore occurs here in a chemically-deposited rock, made up of carbonates of lime and magnesia, with a large percentage of silica, and some alumina: the rock is defined by the author as a magnesian marl, of a pale-grey colour, contrasting vividly with the red clays and sandstones among which it is intercalated. This marl varies in thickness from 1½ to 6 feet. The ore is chiefly copper sulphide, containing no less than 64·2 per cent. of the metal. It impregnates the lignite which occurs in the marl, and the plant-fibres would appear to have been in many cases metasomatically replaced by copper-compounds. Most frequently, however, there is an intimate intermixture of coaly substance and chalcopyrite. Sometimes there are two bands of lignite, sometimes it pinches out altogether. The ore where purest contains as much as 79·8 per cent. of copper, and analysis has revealed the presence of 0·016 per cent. of silver. So far as that district of the island is concerned, only this one cupriferous horizon is known. It is worked in La Rubia mine, which consists of a haphazard labyrinth of galleries, communicating with three comparatively shallow pits, that serve the purposes of drainage, haulage and ventilation. It is not found necessary to use timbering in the mine, as the rocks do not easily fall in.

The Trias covers a considerable portion of the northern area of Minorca, and in this region undoubted occurrences of copper-ore are recorded from various localities over a belt some 17 miles in length. In Lower Triassic times there must have been a great lake here, the waters of which were saline and alkaline, and contained in solution copper-salts, derived either from cupriferous emanations proceeding from volcanic rocks, or from the decomposition of pre-existing metalliferous veins. The lake was probably covered in places with a floating mass of vegetation, and as the plants decayed and fell to the bottom, the organic matter, by reducing the copper-salts, brought about their precipitation in the form of sulphides.

About 15½ miles from Granada, near the road to Guadix, in a mountainous district about 1,000 feet above sea-level are the metalliferous deposits of El Molinillo. The most important ore is a highly argentiferous galena, but there are also cupriferous deposits of the same age, nature and origin as those described in Minorca. Analysis of a sample of chalcopyrite mixed with lignite, yielded 59·76 per cent. of copper. Nothing can be said as

yet as to the possible industrial importance of the copper-ores here, as attention has been so far all but exclusively devoted to the very rich galena-deposits. L. L. B.

IRON-ORES OF RÍO IBOR (CÁCERES), SPAIN.

Datos geológico-mineros de la Provincia de Cáceres: Criaderos de Hierro del Río Ibor. By R. S. LOZANO. *Boletin de la Comisión del Mapa geológico de España*, 1902, *series* 2, *vol. vi.*, *pages* 205-219.

The mines with which this memoir deals are situated in the south-eastern corner of the province of Cáceres, in a mountainous region known as the Sierra de Guadalupe. Ridges of quartzite running south-east and north-west divide a series of narrow, picturesque and fertile valleys one from the other. The greater number of the streams flow into the Río Ibor, which is perennial, and a tributary of the Tagus. Most of the roads are mere wheel-tracks, but there is a good cart-road at Almaraz, which is 8½ miles distant from the railway-station of Navalmoral de la Mata, on the main line from Madrid to Lisbon. The nearest ports of embarkation, Seville and Lisbon, are respectively 159 and 223 miles distant, as the crow flies.

The strata are mainly of Silurian and Devonian age, and iron-ores occur in both series. Hæmatites, frequently manganiferous, infilling fissures or intercalated among the bedding-planes, are found in the basement Silurian quartzites. They are still more abundant at the contact of the quartzites and the slates, and are indicated by gossans exceeding 3 feet in thickness. The ore is extremely tough, more or less silicified, and the manganese-content is often very high. But these Silurian hæmatites of the Río Ibor are not developed in sufficient quantity to repay working on a large scale in modern times. They are neither true vein-deposits nor great mass-deposits.

Along a narrow belt of Devonian limestone stretching for about 25 miles from south-east to north-west, where the basement-beds are highly metamorphosed (dolomite, siderite, etc.), occur manganiferous hæmatites and limonites, which in some localities were known and worked in olden days. There is not much opportunity in these deposits for opencast working now, and most of the mining would have to be done underground. There is no reason to believe that the ore will be found to increase in quality and quantity in depth, but rather the contrary.

The author describes the mines which he visited, being those of San José No. 3 (no good ore visible); Immaculada Concepcion (a specimen of hæmatite from this yielded on analysis 43 per cent. of iron, 1·33 per cent. of manganese, 0·25 of sulphur, and 0·85 of phosphorus), which appears to be the most promising mine of all; San Luis, San Cesáreo, San Antonio No. 2, San Miguel No. 2, San Pablo, San Fabián, San Policarpo, San Juan Nos. 1 and 2, Viriato, San José Nos. 1 and 2, Virgen de la Montaña, Nuestra Señora de Guadalupe, San Ildefonso, San Benito, San Andrès and San Fausto. Taking into consideration that the average percentage of iron in all the ores assayed from these mines is 46½ and that of manganese 4½, the author does not opine that they would repay the very heavy cost of transport under present conditions. The building of a light railway to Seville would cost something like £1,000,000, a sum which could hardly be reimbursed by the output of all the mines in the district put together.

L. L. B.

ROCK-SALT AND OTHER USEFUL MINERALS IN THE MESOZOIC ROCKS OF SPAIN.

Explicación del Mapa geológico de España: Sistemas permiano, triásico, liásico, y jurásico. By L. MALLADA. *Memorias de la Comisión del Mapa geológico de España*, 1902, *vol. iv., pages* 274-305, 504-506.

Taking the geological systems considered in this volume in descending order, we may note the occurrence of hæmatite in the Upper Jurassic limestones of the Sierra de Albarracin (Teruel), and in the Liassic clayey limestones of various localities of the province of Tarragona. These deposits are, however, nowhere of industrial importance. Iron-pyrites occurs in cubes, the sides of which measure as much as 2 inches, in the Bajocian limestones of the neighbourhood of Agreda (Soria) and in the Liassic strata of Anguiano (Logroño). Pyrolusite occurs in a belt about 1,500 feet wide and over 1 mile in length, in clays interbedded with Upper Jurassic limestones, in the province of Teruel. It has been worked in a most irregular and desultory fashion, and subsidences have taken place every now and then, with the result that mining operations have been interrupted for many years at a stretch. A pocket of manganese has also been worked about 1,500 feet east of Coll de Arnat, in the province of Lérida.

Unimportant occurrences of blende, calamine, galena, cupric carbonate, and nickel-ore are recorded from the Jurassic limestones and sandstones of various localities. Of some interest, however, are the lignite-deposits associated with clays and sandstones, intercalated among the Liassic limestones in the provinces of Soria and Zaragoza. Over a length of about 2 miles four principal seams are traced, with dips varying from 40 to 60 degrees north-eastward. These four main seams vary in thickness from 12 to 20 inches, and the mean of three analyses shows the following percentage-composition: carbon 48·1, water and volatile matter 46·48, and ash 5·4. The heating power is equal to 6,368 calories, and this lignite is suitable for purposes which demand the use of a long-flame coal. Unfortunately these deposits are by no means so extensive as they were originally supposed to be, and the author's view of their industrial importance is unfavourable.

Thermal springs of medicinal value occur among the Jurassic rocks of various provinces.

Coming now to the Triassic, we find that in Spain, as in so many other parts of the world, this system is characterized by the occurrence of rock-salt deposits and brine-springs. More than 90 per cent., indeed, of the salt-springs known in Spain well out among the gypsiferous marls and clays of the Trias, from Santander in the north to Málaga and Cádiz in the south. In the province of Santander are rock-salt deposits of considerable thickness (30 to 150 feet). The salt obtained at Imón in the province of Guadalajara is largely consumed in Madrid, but the salt-production of the province could be much increased, were it not for the "inborn indolence of the country-people." A fairly detailed description is given of salt-mines in the provinces of Burgos, Cuenca and Valencia, and of the dried up salt-lagoon of Fuente Piedra (Málaga), etc.

As to metalliferous ores in the Trias of Spain, the most abundant and widespread are the iron-ores, especially in the provinces of Almeria and Murcia. Certain hæmatite-veins which traverse the crystalline schists of the first-named province pass up into the overlying Triassic limestones, becoming richer and less siliceous as they pass upward. The percentage of metallic

iron averages from 45 to 50. It is asserted that in the three provinces of Almería, Murcia and Granada, there are more than 25,000,000 tons of this ore in sight.

Plumbiferous deposits in Spain usually occur in older rocks, nevertheless galena-deposits of considerable importance have long been worked among the Triassic limestones of the Sierra de Gador (Almeria); and lead-ores are found in rocks of similar age in the provinces of Granada, Logroño and Teruel, and in the island of Ibiza or Iviça.

Copper-ores in the Spanish Triassic are of widespread occurrence, but nowhere do they seem to be of industrial importance. The latter statement holds good of the blende and calamine recorded from the provinces of Granada and Almeria, the cinnabar from the Sierra Nevada and elsewhere, the Triassic lignites of Santander, Alicante, etc. L. L. B.

ASBESTOS-DEPOSITS IN SWITZERLAND.

Die Asbestlager der Alp Quadrata bei Poschiavo (Graubünden). By DR. CHR. TARNUZZER. *Zeitschrift für praktische Geologie*, 1902, *vol. x., pages* 217-223, *with 2 figures in the text.*

These deposits occur high up on the divide between Val Quadrata and Val Canciano, in the commune of Poschiavo, in the Canton of Grisons, some 3,300 feet above the village (or 6,800 feet above sea-level), very near the Italian frontier. The asbestos occurs in the Green Slate Series, or serpentinous Malenco rock, as the older Swiss geologists termed it. Mr. Bodmer-Beder recently made an exhaustive microscopic study of the rock, and pronounces it to be a slaty harzburgite-serpentine rock. The same authority considers that originally it was an eruptive mass made up of bronzite, olivine and diopside, altered to its present condition by thrusting and folding, complicated by the metamorphic effects of thermal and aqueous agencies.

The percentage of lime (5·67) yielded by the chemical analysis of the asbestos leads to the inference that the typical mineral hereabouts consists of about 7 parts of chrysotile- and bronzite-bastite asbestos, with 3 parts of tremolitic hornblende and diopside. In some of the mines, however, it is purely tremolitic asbestos, and in other places hornblendic or pyroxenic asbestos. The mineral of Alp Quadrata is commercially valuable, very flexible, long-fibred, silvery-white, or else greyish-brown and yellowish in colour. Some of the fibres reach 2 feet in length. They are, however, deficient in lustre and look like weather-beaten timber. The usual length of the fibres varies between 4 and 8 inches, and the thickness of the deposit is anything between a mere papery film coating the serpentine-rock and a layer 5 inches thick. There occur, however, in places, positive masses of asbestos-rock, wherein the fibres are not so well developed. If allowed to weather on the mine-heap for a time, these masses become suitable (as a second-rate quality) for industrial purposes. The distribution of the asbestos in the matrix is very irregular: sometimes it has been found close to the outcrop, sometimes payable quantities have only been got by working pretty deep down. The asbestos-deposits follow all the contortions and nip-outs, and irregularities of the slaty serpentine.

Six mines were opened up on these deposits, and appear to have all been worked out in 1880; yet the author evidently thinks that mining operations

could be resumed with advantage in some, at any rate, of these. He estimates that the output from the best localities would average 2 to 3 per cent. (of raw asbestos) of the quantity of rock mined. This used to be considered sufficient in the Canadian asbestos-mines, but improved appliances and methods of working have brought the percentages there up to 6, 10 and 15. A Zurich firm obtained in 1901 a concession for re-starting asbestos-mining near Poschiavo, and set about 15 men to work, but no information is yet available as to the results obtained. The author gives reasons for considering the Italian asbestos vastly superior in quality to the Canadian. L. L. B.

THE AGE OF THE TONGKING COAL-DEPOSITS.

Note sur la Flore Fossile du Tonkin. *By* R. ZEILLER. *Comptes-rendus du huitième Congrès géologique international*, 1900 [1901], *pages* 498-501.

The abundant specimens of ferns, horsetails, cycads, etc., recently submitted to the author from the mines of Ke-Bao, Hong-Gay, etc., as well as the discovery of an ammonite, amply confirm the conclusion at which he arrived as long ago as 1882 (but then only on the faith of a few specimens), that the coals worked there are of Rhætic age. The lithological facies of the rocks had induced some geologists to refer them (erroneously, as it now appears) to the Carboniferous system.

Besides these coal-deposits of Lower Tongking, it may be remembered that coal also occurs on the Upper Red river, at Yen-Baï, where it was discovered a few years ago. So far as can be ascertained from the plant-remains found in it, and the associated freshwater mollusca, it is of Middle or Upper Tertiary age. L. L. B.

THE MINERAL WEALTH OF BUKHARA AND TURKESTAN, CENTRAL ASIA.

Notice géologique sur les Richesses Minérales de la Boukharie et du Turkestan. *By* E. D. LEVAT. *Bulletin de la Société Géologique de France*, 1902, *series* 4, *vol. ii., pages* 439-455, *with* 7 *figures in the text and* 1 *plate.*

The author went on a four months' journey, in the first half of 1902, into Central Asia on behalf of the French Government, and unusual facilities were therefore placed at his disposal by the Russian authorities.

Starting from Charjui on the Amu Daria, the author proceeded up that river to the present terminus of steam-navigation, the intrenched camp of Patta Gissar. Landing there, and noting by the way the occurrence of saliferous marls alternating with gypsum-beds, all of Cretaceous age, he followed the river-bank up to Saraï. Turning thence abruptly northward, he soon left behind the great lœss-formation (Quaternary æolian drift) which fringes the Amu-Daria plain, and entered upon an area of Tertiary grits. These gradually pass into enormous masses of gold-bearing conglomerates, the pebbles of which are chiefly derived from diorites and other crystalline rocks. He regards them as being largely of glacial origin, and estimates their total thickness at 5,000 feet. The gold occurs in the form of flakes, generally of small dimensions: nuggets weighing from ¼ ounce to 1 ounce Troy are of rare occurrence. The natives have worked out thoroughly all the deposits above water-level along the river-valleys, and even by the most approved modern methods there is no hope of making a

profit out of the tailings that they have left. Below the river-level, rich deposits remain to be worked, and workings have been started of late years in the Safet-Daria valley, for instance, where the gold disseminated in the conglomerates is found concentrated in pay-gravels some 55 feet thick, which are richest near the bed-rock. The flat form, characteristic in Eastern Bukhara, of the gold-flakes has favoured their transportation for considerable distances along the watercourses. The mass to be worked through is so enormous, that modern plant (such as excavators and dredges) must be used to ensure a profit. Moreover, native labourers, although working at a low wage now, will prove, as experience in Turkestan has shown, much more exacting so soon as they perceive that there is a demand for them. They cannot be depended on to stay at the mines when the season for sowing or the season of harvest arrives, but desert the mines *en masse* whatever offers may be made to them. There are no roads fit for wheel-traffic in Eastern Bukhara, and machinery will have to be brought in, piece by piece, on camel-back.

Passing up from Tabi Dara to the mountain-range named after Peter the Great, the barren grits, etc., of the Lower Eocene are seen to succeed the gold-bearing conglomerates. Reddish marls begin to alternate with the grits, contortions and reversed folds make their appearance in the strata, and indicate that one is approaching the Cretaceous *massif* which closes in the old Tertiary basin. Here again red and green marls alternate with beds of gypsum and rock-salt. The latter mineral is worked at Sagri Dach.

The great Alaï range, with its high peaks and glaciers, is made up of crystalline rocks (gneisses, granites, mica-schists), and crossing this with some difficulty, as the ordinary passes were blocked by the breakdown of bridges, the author reached again the Cretaceous formations in the Sir-Daria basin. Red limestones overlie black shales with outcrops of lignite. At Usht-Kurgan, a coal-seam in the Cretaceous marls is worked: inclusive of partings it is 65 feet thick. The coal-contains 45 per cent. of volatile substances. Near Khokand and Namangan in Ferganah, and also near Merv, borings have been put down for petroleum, and occurrences of ozokerite are recorded from several localities in Bukhara and Turkestan. The natives have obtained petroleum by digging comparatively shallow wells, and always in the neighbourhood of the great mountain-ranges against which the Cretaceous and Tertiary sedimentaries abut.

Numerous outcrops of brown coal and some few of copper and lead-ores are indicated on the author's map. The naphtha and ozokerite-deposits are of Cretaceous age; the brown coal is in some cases Cretaceous, in others Tertiary; and the gold-bearing conglomerates are Upper Eocene.

L. L. B.

THE MINERAL RESOURCES OF THE NORTH-EASTERN ALTAI. (SIBERIA).

Description géologique de la Partie Nord-ouest de la 15me Feuille de Zone VIII. et de la Partie Sud-ouest de la 15me Feuille de Zone VII. de la Carte Générale du Gouvernement de Tomsk (Feuilles Borissovo et Berezovka). By B. K. POLIENOV. *Travaux de la Section géologique du Cabinet de sa Majesté*, 1901, *vol. iii., pages* 133-341.

This elaborate memoir is in Russian, and therefore is a sealed book to a large number of possible readers. It is accompanied by a summary in French, whence the following comparatively meagre details may be gleaned.

The region covered by the sheets of Borissovo and Berezovka of the Imperial survey-map is the north-eastern portion of the province of the Altai. It is cut in two by the river-valley of the Tomi; the south-western half, a level steppe, is chiefly made up of clays and grits correlated with the coal-bearing strata of the Kuznetsk basin, while the north-eastern half is formed by the mountain-slopes of the Alatáu. These slopes are largely made up of Devonian rocks resting against the granites, syenites, gneisses and schists of the main Alatáu range. The Carboniferous strata of the south-western steppe rest conformably upon these Devonian rocks. The Lower Carboniferous is represented by limestones containing a fauna comparable with the Tournaysien and (in part) the Voulsortien of Belgium. It is succeeded by grits, conglomerates and shales, with the last-named of which coal-seams are interbedded and also bands and concretions of sphærosiderite. Prof. Zeiller considers that the plant-remains found in this series are analogous to those characteristic of the Stéphanien of Western Europe. The Kuznetsk group of Coal-measures is immediately overlain by post-Tertiary deposits: loams, sand, lœss and alluvium.

The region appears to have been one of extreme vulcanicity in Devonian times, but there was no volcanic activity during the deposition of the basement Carboniferous. In the Coal-measure period, however, eruptions began again, and molten melaphyres invaded the coal-bearing grits. The coal-deposits have not been worked, so far. In the basin of the Inia river, many scores of coal-outcrops may be counted; the mineral is of excellent quality, the seams are in many cases from 6 to 16 feet thick, and their dip is variable, from *nil* to 60 degrees.

Besides the sphærosiderite already mentioned, deposits of brown hæmatite have been found, also grindstones and honestones, white porcelain-clays, etc. Practically all the most productive gold-placers have been worked out. The precious metal occurs in the alluvium of a great number of the streams which come down from the Alatáu mountains. However, as the actual primary matrix of the gold, the original quartz-reefs (?) remain undiscovered, the gold-mining industry in this area is in a moribund condition.

L. L. B.

COPPER-BEARING VEINS IN TRANSBAIKALIA, SIBERIA.

Die zeolithische Kupfererzformation in Transbaikalien. *By* R. Beck. *Zeitschrift für praktische Geologie*, 1901, *vol. ix., page* 391.

German prospectors have found, in the Chida river-basin in Transbaikalia, what appears to be an industrially-important cupriferous deposit. Amygdaloidal melaphyres, with opaline amygdules, are traversed by veins containing native copper in masses weighing as much as 2¼ pounds, and native silver. This is correlated with the occurrence of native copper sprinkled among zeolites and calcite, recorded two years ago from Transbaikalia.

Concessions have been obtained by the same syndicate, for working argentiferous lead-ores among the crystalline schists, and these have a ferruginous gossan highly charged with gold; also for working graphite-deposits and extensive coal-fields in the district of Naryn. Detailed communications regarding all these occurrences are foreshadowed.

L. L. B.

THE AURIFEROUS REGION OF SIBERIA.

Explorations géologiques dans les Regions Aurifères de la Sibérie. [OFFICIAL.] *Comité géologique, St. Petersbury,* 1900-1901, 324 *pages, and* 7 *maps.*

The elaborate monographs here summarized deal with the Lena, Yenisei, and Amur river-basins; and doubtless the Russian Government purposes to publish further reports on the same scale, dealing with the other gold-bearing districts of Siberia: as, however, the monographs are not numbered consecutively, it is difficult to say where the series begins or where it will end. Of its scientific and industrial value there can be no question.

Mr. A. P. Gerasimov describes the results of detailed investigations made by him in the course of 1900 in the Vacha and Kadali river-basins in the mining district of the Lena. The region is a mountainous one, and is largely made up of pre-Cambrian and Cambrian metamorphic rocks covered by an immense thickness (280 feet) of river-gravels and Glacial Drift. At the base of these alluvial and Glacial deposits, immediately overlying the ancient rocks, is an auriferous stratum, varying in thickness from 2½ to 5 feet, and containing from 4 to 67 parts of gold per million. Thus, the rich placers lie at considerable depths below the surface, and are of pre-Glacial age; but there are also shallow and comparatively poor post-Glacial placers. The Olekma schists are traversed by numerous quartz-veins, which, on the whole, are extremely poor in gold, not to say quite barren of it. Consequently, they cannot be regarded as the original matrix of the gold now found in the placers. On the other hand, the author observes that these same schists are very rich in pyrites, and a specimen of pyrites from the Konstantinovsky placer was found to contain as much as 1,582 parts of gold per million. Whence perhaps it is permissible to infer that the placer-gold was really derived from the pyritiferous schists.

Mr. L. Yachevski deals with the Teya and Enashimo river-basins, in the Northern Yenisei region. Here the most ancient rocks are gneisses and mica-schists, overlain by three successive series of sedimentary origin, with unconformities between each of them. Gold occurs in quartz-veins in the lowermost of the three; it is found dispersed through the shales of the middle series; and it occurs in the red basement-grits and conglomerates of the uppermost series. Moreover, auriferous breccias have been observed in the neighbourhood of faults. But in the area here described the attention of gold-miners has been concentrated chiefly on the auriferous alluvia which are, of course, of immensely more recent date than any of the rocks just mentioned. These alluvial deposits have also yielded diamonds along the Meluichnaya and Tochilny creeks.

Mr. N. Izhitski has examined the Penchenga, Ishimba and Gorbilsk river-basins, in the Southern Yenisei region, and finds that (geologically speaking) the district is of very uniform character. It comprises three great groups of rocks:— (1) The massive crystallines, (2) the metamorphic schists, and (3) the shales, grits and limestones, all folded in a general north-westerly direction. Productive gold-placers are numerous, but mining-industry is at a low ebb, owing to the scarcity of men who combine sound knowledge with a spirit of energy and enterprise.

Mr. A. Meister deals with the Uderei and Udoronga river-basins, also in the Southern Yenisei region. Here too are massive crystalline, metamorphic and sedimentary rocks all folded in a north-westerly direction. Two systems of quartz-veins, crossing each other at right angles, occur, and some of them are auriferous. The author divides the placers of the

district into three groups:—(1) Recent alluvial, in the river-beds—by far the most numerous; (2) ancient terrace-placers; and (3) deep lying terrace-placers, as much as 80 feet down. Some of the shales in the sedimentary rock-group are gold-bearing.

In another memoir, the same author describes his researches in the river-basins of the Great and Little Murozhnaya, the Chernaya, and the Rybnaya. These have led him to the conclusion that the placer-gold there is derived in part from quartz-veins, in part from shales and limestones. The intrusive rocks (diabases and diorites) have played a purely passive part in the enrichment of the rocks. On the other hand, this enrichment is genetically associated with the phenomena of faulting and dislocation.

Messrs. P. K. Yavorovsky and M. M. Ivanov studied the Zeya river-basin in the Amur region, with the following results:—They found a granite-massif overlain by Archæan gneisses (the predominant rocks of the area), Jurassic sedimentaries, and post-Pliocene and recent fluviatile deposits. The area has been intensely folded, and the richness in gold of the placers is intimately connected with the configuration of the folds. Thus the placers near the Ilikan anticline are much richer than those which lie within the radius of the Brianta anticline, where the gold-particles have undergone deformation and pulverization. The precious metal occurs in nearly all the rocks of the gneissose group, but is absent in the Archæan granite and in the diabases and porphyrites which border the Jurassic basin. The quartz-veins are usually very poor in gold, but are productive at the few points where they intersect the post-Jurassic pegmatites and the hornblendites. It is noticeable that those alluvial deposits which strike east and west, parallel with the auriferous bed-rocks, are richer than those which strike north and south across those rocks. The placer-industry promises well, but the prospects of gold-mining in the solid rocks are not hopeful. L. L. B.

MAGNETITE-DEPOSITS IN WESTERN SIBERIA.

Die Magneteisenerzlagerstätten der Hütte "Nikolajewski Zawod" im Gouv. Irkuck (Westsibirien). By TH. VON GÓRECKI. *Zeitschrift für praktische Geologie,* 1903, *vol. xi., pages* 148-155, *with* 6 *figures in the text.*

The Nikolayevski ironworks, at a standstill for the last four years or thereabouts, belonged to a limited company within whose domain (255 square miles) lay magnificent timber-forests, as well as the magnetite-deposits about to be described. This "little principality," as the author terms it, is situated in the Nizhnye-Udinsk district of the Government of Irkutsk. Water-communication with the city of Irkutsk (420 miles distant by river) is secured by means of the Dolonovka, a sub-tributary of the Angara. The nearest railway-station (Tulun) is some 132 miles away. In 1899, no less than 1,700 persons were employed on the estate, and without reckoning steel-rails, the weight of material sold was 4,545 tons. Three blast-furnaces were at work, on ores chiefly obtained from the Yermakovski mine. The other three mines belonging to the company were known as the Dolonovski, Keshemski and Krasnoyarski mines respectively.

The Dolonovski was the first iron-ore deposit to be discovered in that region. Here quartzitic Devonian sandstones have been highly altered by contact-metamorphism. Indeed, they are described as presenting a slaggy

appearance, due to the eruption of a rock belonging to the group of the olivine-diabases and known as "Siberian trap." This "trap" occurs in more or less extensive sheets over a considerable area, from the Oka river-basin to that of the Kan. With this trap is associated on the Dolonovski hill a porphyrite containing innumerable glass-inclusions, and finally tuffs and breccias, amid which is magnetite occurring in bands 10 inches or so thick, alternating with bands of calcite and quartz, The total thickness of the ore-deposit does not probably exceed 10 feet, but sometimes the entire thickness consists of magnetite without any bands of calcite or quartz. Opencast workings were carried down to a maximum depth of 65 feet, and the deposit was seen to continue deeper still. It may be regarded as consisting of two great reefs, which apparently cut each other at a rather wide angle. The author is inclined to recommend further exploration-work, and points out that the average analysis of the ore shows 58·3 per cent. of metallic iron. It contains 0·44 per cent. of phosphorus, and 3·3 per cent. of silica.

The rocks in the neighbourhood of, and forming, the Yermakovski hill (1,770 feet above sea-level) are of much the same character as those just described. The ore-deposits here attain a maximum thickness of 25 feet or so, and four distinct reefs are traced, three of which cross the main one at various angles. Analyses show the ore to yield 65·23 per cent. of metallic iron. Phosphorus is apparently absent, and the percentage of silica is 2·03.

In both mines, the magnetite is intimately associated with volcanic tuffs and secondary breccias—and the author traces a more immediate connection between the ore-deposit and these clastic rocks than between it and the outpourings of Siberian trap and the associated augite-porphyrite.

Some 30 miles farther north is the Krasnoyarski deposit, of comparatively recent discovery. Here again the ores are banded, with intercalated calcites, and the maximum thickness of the ore-body revealed by the opencast workings exceeds 13 feet. The "vein" strikes 115 degrees north-west, and pitches south-westward 75 degrees. The country-rock is a breccia of vitreous fragments cemented together by calcspar, magnetite, chlorite and zeolites. The average chemical analysis of the ore shows 55·99 per cent. of metallic iron, 5·69 per cent. of silica, but no phosphorus or lime.

About 20 miles away to the north-east of the Krasnoyarski mine lies that of Keshemski Rudnik, considered of sufficient importance to have warranted the laying out in its neighbourhood of the ironworks known as the New Nikolayevski Zavod. (The Old Nikolayevski Zavod is situated near the Dolonovski mine.) Here only one very thin band of calcite occurs in the ore-body, which consists of a maximum thickness of 15 feet of nearly pure magnetite. The country-rock is again a breccia of volcanic fragments cemented largely by magnetite, which yields place to calcite and chlorite as the distance from the ore-body increases. On analysis the ore yields 61·72 per cent. of metallic iron, 3·97 per cent. of silica, but neither phosphorus nor lime.

The genesis of these rich ore-deposits is discussed in detail, and the author ranges them among the epigenetic variety, that is, ores which may be regarded as infillings of fissures and cavities. He compares them with the deposits of Traversella in Piedmont and Calamita in Elba, and considers that they were precipitated from thermal waters, which represented the moribund stage of vulcanicity in this area. The veins may be truly termed

"infiltration-veins," and fine pseudomorphs of magnetite after hæmatite have been observed in the Keshemski mine, for instance.

It may be predicted that the completion of the great Siberian railway will probably give rise to renewed mining activity in this now less-remote region of Western Siberia. L. L. B.

PHOSPHATIC, ASPHALTIC, AND PETROLEUM-DEPOSITS IN PALESTINE AND EGYPT.

Über das Vorkommen von Phosphaten, Asphaltkalk, Asphalt und Petroleum in Palästina und Ägypten. By DR. M. BLANCKENHORN. *Zeitschrift für praktische Geologie*, 1903, *vol. xi., pages* 294-298, *with* 1 *figure in the text.*

Within recent years, the Campanian or Middle Senonian (Cretaceous) limestones of Palestine have been found to contain rich deposits of phosphate, besides the bitumen which occurs in some of the limestone in payable quantity. It may be noted, by the way, that the phosphate-deposits of Algeria and Tunisia are found at a higher horizon, in Lower Eocene or Suessonian beds, which are barren in Palestine.

Phosphates of the same age as those discovered by the author in Palestine in 1894 were found in 1897-1899 by the officers of the Egyptian Geological Survey at several remotely-situated localities in Egypt, but he considers those of Palestine as in part of better quality and much more favourably placed from the industrial point of view.

He mentions an exposure on the high plateau of the Eastern Jordan region, about 3,000 feet above sea-level, yielding a phosphate of the following composition: phosphorus pentoxide, 36 per cent.; lime, 53 per cent.; alumina and iron sesquioxide, 1·12 per cent.; calcium fluoride, 9·8 per cent.; calcium sulphate, 1·86 per cent.; and insoluble residue, 0·46 per cent. At a locality known to the author in Judæa, within a thickness of 23 feet there are three bands of phosphate, respectively 20 inches, 40 inches and 45 inches thick, yielding a mineral which contains from 45 to 50 per cent. of tribasic phosphate of lime, 43 per cent. of carbonate of lime, about 2·5 per cent. of alumina and iron oxides, and 3 per cent. of silica. The cost of working the Palestinian phosphates would be very small, for reasons which are indicated.

The deposits described by the Egyptian Survey occur in Sinai, in the Arabian Desert (about 7 miles from the Red Sea), west of the Duwi range (31 miles north-west of Qosseir), also north-east of Qeneh, 6 miles from Qift or Quft railway-station, and lastly in the Dahla oasis of the Libyan Desert. The bituminous or asphaltic limestones associated with the calcareous phosphates of Palestine occur in "inexhaustible quantity" along a belt parallel to the Dead Sea and the Jordan valley. At Nebi Musa, the percentage of bitumen in the rock attains a maximum of 25. The author believes that the mineral will be found very suitable for street-paving purposes, and experiments to that end are shortly to be made in Berlin.

The asphalt of the Dead Sea region fetches high prices on the world's markets, and yet no systematic working of it on a large scale has yet been attempted.

Of greater importance even than the deposits already mentioned for the future of Palestine would be the development of the petroleum-industry. Theoretically, it seems to the author more than probable that borings put down on the eastern and western shores of the Dead Sea would strike

oil: the stratigraphical, mineralogical, chemical and climatic conditions of the region all point to successful prospecting for petroleum. Oil oozes out at the surface of the ground at several points, and the author describes one spring, the locality of which is at present only known to himself and a few of his fellow-countrymen.

The petroleum of Gebel Sēt on the Gulf of Suez appears to be of much later age than, and of an entirely different origin from, that of the petroleum of the Dead Sea area. Nor does it appear that borings in the neighbourhood of Gebel Sēt are ever likely to yield oil in payable quantity.

The paper generally is intended to call the attention of German capitalists to Palestine, more especially than to Egypt, as a field of future mining enterprise. L. L. B.

THE COAL-FIELD OF HERAKLEA, ASIA MINOR.

Das Steinkohlenbecken von Heraklea in Kleinasien. *By* BRUNO SIMMERSBACH. *Zeitschrift für praktische Geologie*, 1903, *vol. xi., pages* 169-192, *with* 12 *figures in the text.*

This coal-field is situated in the north-western portion of Asia Minor, very near to the coast of the Black Sea, from which in places it is barely more than ½ mile distant. The seams are numerous, often very thick, and furnish a coal which is variously compared by experts to Cardiff and to Newcastle coal. The coal-bearing belt, some 3¾ miles wide, extends for 93 miles from south-west to north-east, but the total annual output so far only averages 160,000 tons, whence it may be inferred that an enormous area is still practically untouched

The author follows Mr. G. Ralli in subdividing the Heraklean coal-formation into three stages:—(1) The lower, or that of Alaja-Agzi; (2) the middle, or that of Koslu; and (3) the upper, or that of Karadon. The lithological facies resembles that of most European coal-fields, the strata consisting mainly of various sandstones, generally light-coloured, and fossiliferous carbonaceous shales. It is already demonstrable that a large number of excellent coal-seams continue the whole length of the belt, from Heraklea to Amasra. In the Koslu group, for instance, are six important seams, the thinnest of which is 6 feet thick, while the others range from 10 to 13 feet. Almost everywhere the seams strike north-east and south-west, with a moderate dip, varying between 10 and 12 degrees, although occasionally this steepens to the vertical.

It has been found that, on long sea-voyages, the Heraklean coal, which is very light and burns with a long flame, deteriorates in quality; but the results of the experiments made with it by various foreign fleets (especially the French) have not given rise to any complaint. It would also appear that the coal improves in quality the farther inland that it is worked; and that portion of the field which lies farther south, away from the Black Sea, has not yet been worked.

A series of ten chemical analyses shows the percentage of carbon to vary from 51 to 64, that of volatile matter from 27·6 to 45, and that of ash from 4 to 11·4. But all these samples were taken from the actual outcrops, and do not fairly represent the quality of the perfectly-fresh mineral got from below the surface.

Entering then into greater detail, the author describes the Alaja-Agzi or lowermost group, called after the locality of that name, where at least

nine seams of a total thickness of 37½ feet have been proved. The thickness of strata intervening between the top seam and the bottom one is estimated at about 650 feet. The bottom seam thins out close to the seashore. How much deeper down coal may yet be struck is not yet known, but for various reasons the presence of lower seams yet at Alaja Agzi is shown to be probable. The seams here strike generally east and west, with a southerly dip of 15 to 30 degrees. Farther east, at Kirechlik, four seams have been proved exceeding 3½ feet in thickness respectively, and other thinner seams are known. They dip as much as 80 degrees southward, and strike north—70 degrees—east, that is nearly across the general strike of the Alaja-Agzi district. They are not found at that locality itself, nor at Teflenti: they lie, in fact, much deeper than the known seams of those areas, which again recur in the little valley of Kirenlik. Seven analyses of coal from the lower group are tabulated: the percentage of ash varies from 2 to 9·75; that of hygroscopic water from 1·5 to 2·75; that of volatile substances from 35·4 to 42·8; and that of coke produced, from 57·2 to 64·6. In three samples, the coke was porous and tumescent; in five samples the ash was brown and in one yellowish-brown. At this stage, one disadvantage of the Heraklean coal is mentioned—its proneness to evolve great clouds of black smoke when used for boiler-firing, etc. No experiments have been made with it in regard to the production of gas for illuminating purposes, but the author thinks it especially suitable for such purposes. The mineral is usually somewhat hard, and yields a brown streak. The higher lying seams of the Alaja-Agzi group contain a smaller percentage of volatile substances than the lower lying ones, in contradistinction to the usual experience in coal-fields. Evidence is adduced to show that the geological age of the group is that of the Upper Kulm.

Coming now to the middle group, we learn that exploration-work has been pushed forward at Koslu and in the neighbouring valleys more than anywhere else in the coal-field, and an enormous number of seams have been proved. The boundaries of this portion of the coal-field, so far as at present known, are formed by two great faults, a northern fault and a southern: the coal-outcrop has been traced for a distance of 12½ miles along one of these. On the western slopes of the Uzulmez range, in the neighbourhood of the State Railway, coal-seams have been worked since 1854 without showing signs of exhaustion. The Mulazim seam, 6½ feet thick, of pure coal, is one of those that are as yet practically untouched. The author tabulates, after Prof. Ralli, 54 analyses of coal from the Koslu group. These show percentages of ash varying from 2·5 to 13·25; hygroscopic water from 0·75 to 2·5; volatile substances from 28·5 to 39·8; coke produced, from 59·7 to 71·5. On the whole, the mineral may be regarded as an exceptionally superior quality of gas-coal. The author himself adds numerous other analyses, the results of which are sensibly identical with the foregoing. The palæontological evidence has shown that the Koslu group occupies an intermediate position between the lower and middle stages of the Westphalian Coal-measures.

The Karadon or Upper group may be regarded as divided from the middle group by a mass of conglomerate some 330 feet thick, the dip of which gradually increases in steepness until it reaches the vertical at the great southern fault. On the further side of that appear the first coal-seams of the Karadon group, and their fossils show them to belong to the lowermost portion of the true Upper Coal-measures. Four main seams in this group are known,

pretty close together, and varying each in thickness from 3 to 5 feet or so. The author tabulates 16 analyses, wherein the percentage of ash varies from 2·5 to 12·25; that of hygroscopic water from 1 to 6·5 (exceptional); that of volatile substances from 29 to 52·6; and that of coke from 47·4 to 71. The ash has a generally characteristic pale-grey colour.

The Amasra district forms the easternmost extremity of the Heraklea coal-field, so far as at present known. Here at least five coal-seams have been proved, varying respectively in thickness from 3 to 8 feet or so. The average percentage of three analyses is as follows:—Ash, 6·05; hygroscopic water, 6·1; volatile substances, 39·2; coke produced, 60·7.

Among the obstacles which stand in the way of the full development of this magnificent coal-field, are the inherent apathy and conservatism of the Turks, and the unreliability of the labouring classes, who will only work uninterruptedly for a fortnight or so at the mines, and then go back to their native villages, careless whether others are ready to take their places or not.

The paper is illustrated by a map and detailed vertical sections of the coal-seams. L. L. B.

METALLIFEROUS ORE- AND COAL-OCCURRENCES IN SOUTH-EASTERN ASIA MINOR.

Geologische Studien im Südöstlichen Kleinasien. By DR. FRANZ SCHAFFER. *Sitzungsberichte der Mathematisch-naturwissenshaftlichen Classe der kaiserlichen Akademie der Wissenschaften* [*Vienna*], 1900, *vol. cix., abtheilung I., pages* 498-525, *with 2 maps in the text.*

From this account of a journey of natural-history exploration undertaken by the author in Cilicia and Cappadocia in the spring of 1900, the following references to ore-deposits, etc., may be extracted. (He points out in the first place that, even now, the region is from the geological point of view but little known.)

The serpentine which underlies the Miocene limestones near the headwaters of the Sunturaz-Chai contains chrome-iron-ore at Kairak-Keslik. Farther north, in the Allah-Dagh are veins of hæmatite.

Journeying from Tarsus, along the course of the Chakyt-Chai, up towards the Cilician Gates (*πυλαὶ κιλικίης*), older Tertiary limestones are met with at Koerli, containing iron-ores.

At Aiwabé-Han, in the river-bed of the Aiwabé, occur thin seams of a deep black "brown coal," with a pitchy lustre. This occurrence, however, is not considered to be of industrial importance. The coal-bearing marls are traced for 6 miles or more as far as Bozanti, and at Belemedyk (on the middle course of the Chakyt-Chai) they contain rather thicker seams.

The grey freshwater marls on the plateau between Nemrun and Zibil contain thick seams of "brown coal"; the author estimated a workable thickness of 5 feet. The coal is of a lustrous black, very brittle, laminated, and after some exposure to the atmospheric agencies disintegrates into a crumbly mass. Although the lie of the seams is much disturbed, there is reason to believe that they extend over a considerable area. They are probably of the same age as those of the Aiwabé valley, and one may conclude that there is a continuous belt of these older Tertiary land- and freshwater-formations along the base of the main mountain-range from Zibil up to the Ak-Dagh. Similar coal-bearing marls are also found at Kara-Sis.

L. L. B.

THE MINERAL RESOURCES OF THE PORTUGUESE COLONIES.

As nossas Riquezas Coloniaes. By JOSÉ DE MACEDO. *Boletin da Sociedade de Geographia de Lisboa*, 1901 [1900], *series* 18, *pages* 411-610.

The fourth chapter of this exhaustive memoir on the oversea possessions of Portugal gives in some 22 pages a compilation of all the available facts and opinions (more or less speculative) in regard to their mineral wealth. Concerning ourselves with the facts alone, we note in the first place that trustworthy scientific information as to these Portuguese colonies is somewhat scanty. The Cape Verde Islands, for instance, "are said to contain" deposits of iron- and copper-ores, silver- and gold-bearing ores, native sulphur, etc. Ferruginous springs are abundant there; salt has been exported in large quantities from Bõa Vista and the Ilha do Sal, but the author gives no clear explanation as to how the salt is got.

In Portuguese Guinea are petroleum-springs, as yet, untapped. Gold is, of course, the best-known mineral product of that region; nothing positive can be stated as to other metals there. In San Thomé and Principe there are deposits of mercury and manganese-ores, rock-salt, petroleum, etc.

Angola has long been known as possessing considerable mineral resources, among which are the coal, rock-salt, hæmatite and copper-ores of Mossamedes, etc., the magnetite of Gambos, and the native sulphur of Benguella. Petroleum of excellent quality occurs, chiefly in the Dondo district.

Turning then to East Africa, the author is unable entirely to resist the temptation which besets most of those who have lately written on that part of the world, to share in the controversy regarding the original site of the land of Ophir. He appears to think that it embraced most of the country northward from the Cape up, and including Mozambique.

Concerning Mozambique, it is pointed out that in 1899 the following mining concessions were granted:—6 for working coal, and 10 for working copper- and silver-ores, gold- and diamond-reefs. At present 61 mining concessions are in force in the province. That part of Manicaland which has remained Portuguese territory is "incomparably richer" in gold, silver, copper, iron, etc., than the portion which now belongs to the British Empire; and it is asserted that a certain gold-mine in Portuguese Manicaland obtains yields which are superior to anything ever got in the Transvaal. The districts of Lourenço Marques and Cabo Delgado are also said to be rich in coal and other minerals.

The little Portuguese possessions in India contain coal, iron- and copper-ores, but not in sufficient quantity to found a great industry upon them. In the island of Timor, five petroleum-springs are known on the southern coast, in close proximity one to the other. There is also native sulphur of excellent quality, coal, a little gold, iron-, copper- and silver-ores.

L. L. B.

THE BORACIC DEPOSITS OF THE SALINAS GRANDES, ARGENTINA.

Gisements de Borate des "Salinas Grandes" de la République Argentine. By H. BUTTGENBACH. *Annales de la Société géologique de Belgique*, 1901, *vol. xxviii., Mémoires, pages* 99-116, *with* 4 *figures in the text.*

The Salinas Grandes are vast salt-marshes, situated on a high desert-plateau in the region where the frontiers of Argentina march with those of Chile and Bolivia. They are bounded on the east and on the west by lofty

snow-capped mountain-ranges, and they are in 23 degrees south latitude and 68 degrees west longitude of the meridian of Paris.

In the centre of these basin-like marshes, the ground is perfectly flat, and is covered by a deposit of rock-salt which reaches a maximum thickness of 13 inches or so. The water which floods these marshes from December to March runs off or percolates through them very rapidly, and they dry up quickly, thanks to the generally high temperature of the air during the daytime, thanks also to the action of the winds which sweep resistless across the plateau. Vegetation is of the scantiest description—mere desert-scrub, and sand-storms are frequent.

The upper portion of the rock-salt bed is grey, but the lower portion is white, very pure, with good cleavage. It is got out in blocks, the sides of which measure about 16 inches, and finds a ready market in the neighbouring provinces of Salta and Jujuy. The salt-bed diminishes in thickness from the centre of the basin towards the periphery, and where it dies out the borate-deposits come in: these are now being worked, for the most part by the International Borax Company.

The mineral is a hydrated borate of lime and soda, containing a little magnesia, calcium carbonate and sodium sulphate, and highly impregnated with common salt, the elimination of which, however, is easy. The author discusses in some detail the question as to the exact species to which the mineral can be referred, and finally decides in favour of ulexite, the chemical formula of which is $Ca_2Na_2Bo_{10}O_{18}(H_2O)_{16}$. Moreover, the results of a crystallographic examination under the microscope point in the same direction, the distinctive characters of ulexite being very marked.

This ulexite of Salines Grandes occurs in nodules which, from their resemblance in form to potatoes, are called *papas* by the workmen. As a rule, they are about the size of a man's fist, but are sometimes as big as a child's head. They are agglomerated together into beds varying from 4 to 28 inches in thickness, and lie in a matrix which varies from a slightly clayey loam to a sticky clay. This boracic deposit is never found at a greater depth than 5 feet below the surface, and rests upon a barren bluish clay of unknown thickness. There appears to be no sort of regularity in the number, thickness, or relative position of the masses of borate within the limits just indicated, and on the whole the deposit is fairly comparable with that of Columbus Marsh in California.

When the boracic nodules are dug out they are damp, plastic, and highly saline. If left exposed, however, to the sun and air for not less than 5 and not more than 20 days they become hard, lose about 20 per cent. of their weight, and when they are shaken up in a basket the earthy matter clinging to them crumbles away. They then contain at most 2 per cent. of common salt. Sometimes the nodules are cemented together by (and impregnated with) a hard material called *caliche* by the workmen. This consists largely of sodium nitrate, gypsum, glauberite, pickeringite and rock-salt.

The author discusses in some detail the various explanations that can be given to account for the origin of these deposits, and points out that the intervention of volcanic phenomena is, in any case, necessary to account for the presence of boric acid. Further, he believes that the formation of ulexite-nodules is still going on, and that this formation is conditioned by the annual flooding of the marshes during the rainy season.

L. L. B.

SAFETY-APPLIANCE FOR WINDING-ENGINES.

Sicherung des Förderbetriebes durch besondere Apparate. *By* A. SCHLÜTER. *Glückauf*, 1902, *vol. xxxviii.*, *pages* 444-452.

To reduce the pressure that has ordinarily to be overcome by the governors in releasing the stop-mechanism in safety-appliances for winding-engines, the author provides a horizontal governor controlling the movement of a rotable collar on a fixed guide-rod. To this collar is attached a disc carrying the pawl of the releasing-gear and capable of adjustment so that, when any given speed is exceeded in winding, the brake and cut-off gear of the engine is brought automatically into action. Should the cage be travelling too fast near the end of the trip, or be overwound, the collar is pulled round by a swing-hook actuated by a friction-bowl and adjustable sloping-planes on the back of the depth-indicator. This movement of the collar releases a check-pawl, which, in turn, releases a weight that actuates the throttle-valve and brake-mechanism. If the cage is gradually slowed down near the end of the trip, the collar does not come under the influence of the swing-hook. On the other hand, when the cage-velocity exceeds the maximum limit, the collar is pushed by the governor far enough to release the check-pawl, and actuate the cut-off and brake-gear. Two sets of pinions are provided for use in winding men and coal respectively, and the cage-velocity is shewn on a scale on the dial of the depth-indicator. C. S.

SAFETY-APPARATUS FOR WINDING-ENGINES.

Sicherheitsapparat für Fördermaschinen: System Wodrada. *By* PROF. K. HABERMANN. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1901, *vol. xlix.*, *page* 227.

An apparatus has been designed by Mr. F. Wodrada to prevent the cages in mines from being wound too high, or raised too quickly. It is worked automatically by the winding-engine in such a way that if the cage be overwound, or the maximum permissible speed exceeded, the brake acts, and the admission of steam is cut off at the same moment. The apparatus is placed near the cage-indicator, and consists of two vertical racks placed behind the indicator-spindle, connected to each other and to a ball-governor. At the bottom of each rack is a pulley worked to and fro along a horizontal lever by the governor. If the speed of the engine (and of the governor) increases, the racks approach the indicator-spindle; if it falls, they recede. The position of a nut on the spindle corresponds with that of the two cages in the shaft. This nut carries a knife-edge which, if the normal speed of the cage is exceeded, catches in the lower edge of the rack, and presses it down. A lever is thus set in motion, throws on the brake, cuts off the admission of steam, and the engine is stopped. It is also thrown out of gear if the proper speed is exceeded, and the cage wound up too quickly. The ball-governor then acts on the racks, and the knife-edge throws on the brake as before. To adjust the apparatus for different speeds of the cage without varying the sensitiveness of the governor, there are two pulleys of different diameters running loose on the motor-shaft, and connected to two others on the shaft of the governor. One or other set can be brought into play by a hand-lever. For winding up men, when the cage rises more slowly, the larger pulleys are used, and the smaller for winding up minerals. The racks also produce a gradual slackening of the speed as the cage ascends.

E. M. D.

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A.M.N.H.

APPENDICES.

I.—NOTES OF PAPERS ON THE WORKING OF MINES, METALLURGY, ETC., FROM THE TRANSACTIONS OF COLONIAL AND FOREIGN SOCIETIES AND COLONIAL AND FOREIGN PUBLICATIONS.

CONTACT-METAMORPHIC ORES OF BALIA MADEN, ASIA MINOR.

Beiträge zur Kenntniss der contactmetamorphen Lagerstätte von Balia-Maden. *By* G. BERG. *Zeitschrift für praktische Geologie*, 1901, *vol. ix., pages* 365-367.

The author describes the macroscopic and microscopic characters of some of the specimens from this ore-deposit, which are in the possession of the Freiberg Mining Academy.

The sulphidic ores are predominantly galena, iron-pyrites and blende. Copper-pyrites also occurs, and arsenic fahlore is associated with some of the coarsely-crystalline galena and iron-pyrites. Among the oxidic ores, that one to which the author draws special attention is smithsonite, occasionally encrusted with calamine, and betraying (by the blowpipe-test) the presence of a considerable proportion of cadmium.

The country-rock is represented by fossiliferous Carboniferous Limestone, granular limestone, and a recent tufaceous freshwater limestone. There is also a specially interesting (from the petrographic point of view) calcium-silicate rock which occurs in the contact-zone of the augite-andesite. It contains epidote, garnet, pyrites and galena, and shows that the pyrites was formed almost at the same time as the garnet, after the epidote had crystallized out. The galena was formed much at the same time as the anorthite-felspar, for both minerals make up the cement which fills the interstices between the older constituents. But, whereas the anorthite occurs in the more garnetiferous portions of the rock, the galena is almost invariably associated with the pyrites. This rock was doubtless originally a limestone. L. L. B.

COPPER-ORES IN PORTUGUESE WEST AFRICA.

Das Kupfererzvorkommen bei Senze do Itombe in der Portugiesischen Provinz Angola, Westafrika. *By* F. W. VOIT. *Zeitschrift für praktische Geologie*, 1902, *vol. x., pages* 353-357, *with* 1 *figure in the text.*

Senze do Itombe is situated on the Loanda and Ambacca railway, 117 miles distant from the former town, which, besides being the capital of the province of Angola, ranks also as a seaport. One train runs daily thither, taking 12 hours to accomplish the journey. The ore-deposits lie 1½ miles west of Senze, but only ¾ mile distant from the railway-line.

The author gives a brief description of the physiography and climatic conditions of the region, and then describes fully the geology of the more immediate neighbourhood of Senze. Under a thick mantle of alluvial and drift-deposits lie in descending order:—(1) White, fine-grained, calcareous

sandstones, (2) iron-stained quartzose conglomerates, frequently interbedded with micaceous marls, and (3) fine-grained sandstones, partly calcareous and micaceous. All these beds contain fossils, by means of which the group of strata has been assigned to the Upper Cenomanian division of the Cretaceous series.

The copper-ore occurs mostly in connexion with the conglomerates, and cupric carbonates (associated with carbonate of lime and kaolin) form the cementing-material of the rock. In some exposures, the conglomerates are so completely impregnated with copper-ore that they may be regarded as ore-beds. Near the outcrop, the ores are chiefly malachite and azurite, but these are the secondary products of sulphidic ores: in fact, in places the original copper-glance is found, the proportion of it increasing as one goes deeper down. The chemical reactions set up by the percolating surface-waters, more particularly active under tropical conditions, account for the transformation of the sulphidic into oxidic ores nearer the outcrop (down to a depth of 36 feet or so). As the strata dip south-westward, the cover increases in thickness in that direction, and one may therefore expect to meet with a thinner but more richly-metalliferous bed along that line. So far as mining operations have gone at present, on the gossan, pockets of ore containing from 12 to 18 per cent. of metallic copper are found to alternate with sparsely-impregnated beds containing only 1 or 2 per cent. of the metal. The author speaks hopefully of the probable amount of sulphidic ores available, and he mentions an occurrence of limestone-gravels completely "saturated" with copper-ores, about ½ mile north of the main deposit. This northern deposit appears to be an instance of metasomatic replacement of limestone by copper-compounds. The water-supply of the neighbourhood of the mines is amply sufficient for industrial purposes. L. L. B.

THE AURIFEROUS DEPOSITS OF RAPOSOS, BRAZIL.

Beiträge zur Kenntniss der Goldlagerstätten von Raposos in Brasilien. By GEORG BERG. *Zeitschrift für praktische Geologie*, 1902, *vol. x., pages* 81-84, *with* 5 *figures in the text.*

The deposits of Raposos, east of the Rio das Velhas, are perhaps among the least-known of the auriferous occurrences which enrich the province of Minas Geraes in Southern Brazil. It is true that the gold-output of Raposos can hardly be termed considerable, but the mode of occurrence of the auriferous pyrites is interesting: the ore is found in more or less cylindrical "pockets" which are traced obliquely downward through the rocks.

The predominant strata of the district are grey pre-Cambrian clay-slates and phyllites, sometimes represented by chlorite- and sericite-schists, with which are interbedded itabirites and various quartzites. The itabirites are so highly charged with magnetite that surveying-work with the compass-needle is practically impossible throughout the district. The quartzites vary in character from finely-schistose to coarsely-granular, the latter variety containing a remarkably large proportion of calcite. The slaty rocks are traversed by two diabase-dykes, and the slates continue with the same strike and petrographical character across country into the important gold bearing rocks of Morro Velho.

Now, the slates of Raposos have been much folded, thrust and sheared

and it is in such sheared portions that the pockets of ore occur, measuring generally between 10 and 20 feet, though in some cases they may measure as much as 40 feet, and in others as little as 8 inches. The "pockets" are arranged in rows parallel to the strike of the slates, and are infilled with quartz and pyrites, predominantly iron-pyrites. The quartz forms the nucleus of the "pocket," and is microbrecciated; the largest "pockets," however, instead of being directly enveloped by the slate, have a peripheral layer of fibrous quartz or quartzite. Arsenical pyrites is not of uncommon occurrence at Raposos, and its presence there is welcomed by the miner, as it contains a high percentage of gold. Of subsidiary importance only are the occurrences of chalcopyrite, magnetic pyrites and zinc-blende. The magnetic iron-ore, which is most probably the residuum of leached-out itabirites, is a frequent associate of the ore-pockets. Occasionally also geodes are found, containing true vein-quartz with auriferous pyrites, and very small nuggets of native gold.

There is no evidence to show that the "pockets" are mere widenings or bellyings of fissure-veins. On the other hand, quite independently of the lie and arrangement of these "pockets," small pyritiferous veins course through the country-rock and some of the unsheared slates are found to be impregnated with pyrites. It seems probable that the Raposos ores are the result of the percolation of metalliferous solutions (genetically connected with the diabase-eruptions) among the sheared schists and quartzites, and the author ingeniously explains how both "pockets" and small veins can thus be accounted for.

Down to depths of 10, 20 feet and more, the surface-rocks in this tropical area (19 degrees 58 minutes south latitude) are weathered and decomposed almost beyond recognition, and at one time the gold was got by simply washing these loose "lateritic" surface-deposits. L. L. B.

THE CUPRIFEROUS DEPOSITS OF CHUQUICAMATA, CHILE.

Asiento Mineral de Chuquicamata. *By* CÁRLOS G. AVALOS. *Boletin de la Sociedad Nacional de Mineria, series* 3, 1901, *vol. xiii., pages* 145-153.

The mines of Chuquicamata have increased enormously their output within the last year or two, owing to the stimulus afforded by the rise in the price of copper. An output which averaged annually 5,000 tons (containing 18 per cent. of metallic copper) previous to 1899, reached in that year and in 1900 respectively 18,000 tons of about the same quality. The output for 1901 is estimated at 25,000 tons containing 17 to 18 per cent. of metallic copper. The slight increase recorded of late in the copper-output of Chile is due to these mines alone, the production of other and older mines in that country having diminished or remained stationary.

Chuquicamata lies 12½ miles north-west of Calama station, on the railway-line from Antofagasta into Bolivia. Calama marks the southern limit of the pluvial region of the Bolivian high plateau; southward and westward of it stretches the great desert of Atacama. The neighbourhood, of itself, offers no inducement to the agriculturist, but in consequence of the development of the mining industry strenuous efforts are being made to modify the natural conditions of the soil, so as to establish on the spot the necessary food-supply, etc. for a vast mining population. The Rio Loa, coming down from the snow-clad Andes, will furnish with its numerous

water-falls a good source of motive power, and its flow is so regular and so abundant that it can be used for irrigation as well. The district, moreover, is rich in deposits of sulphur, hydroboracite, sulphates and nitrates of soda, whence the reagents necessary for treating the ores either in the dry or the wet way could be obtained. A small branch from the Antofagasta railway runs very nearly up to the mines, but as the intervening distance has to be traversed in carts, entailing increased cost of transport, many mine-owners prefer to send their output direct to Calama by road, instead of availing themselves of the small branch-railway. It would appear that the owners of the last-named at present control in some way the water-supply to the mines, and the author appeals to Government intervention as the remedy for the present state of matters.

The metalliferous deposits extend over an area of 2½ miles from north to south and 1 mile from east to west: but, in the latter direction especially, fresh discoveries are continually enlarging the boundaries of the mining-field. The district is one of low undulating hills with a general southerly slope, cut by gullies. The surface, down to a depth of 7 feet or so, is made up of very recent detrital material, the débris of the neighbouring rocks. The existence of this superficial mantle concealing the mineral outcrops explains how it is that their number and importance have been recognized only by slow degrees. Below it occur the granites, pegmatites and syenites, which are the true country-rock of the Chuquicamata ores.

These ores occur as true veins, the main strike of which is north and south, although the San Luis, one of the most important, runs east and west. In thickness they vary from 3 to several feet (at the intersections, etc.): near the surface they yield a natural sulphate of copper, lower down a sulphate of copper and soda (krönkite), deeper still and in far greater abundance atacamite, the oxychloride of copper. At a depth of about 200 feet, occur the black oxide and the sub-sulphide of copper with a ferruginous gangue; at 330 feet (the greatest depth so far attained at Chuquicamata) occur copper- and iron-pyrites.

The central portion of the field is taken up by what are known as *llamperas*, the rocks being traversed in every direction by a multitude of small fissures, filled with copper-ores exhibiting the same varietal succession in depth as was noted in the case of the true veins and having doubtless the same origin. In fact the *llamperas* are regarded by the author as the upward or lateral prolongation of the less numerous but far more considerable fissures constituting the true veins, and there is reason to believe that more of such veins will be ultimately struck by following the *llamperas* downward.

The principal mine is the Poderosa, with a monthly output of 300 tons containing 20 per cent. of metallic copper. In this and in the Zaragoza and Emilia mines, work is being actively pushed forward, with a view to an extension in depth when it is hoped to reach the sulphidic ores. Moreover, it is possible that in this way an artesian water-supply will be tapped.

The author thinks that a brilliant future lies before the copper-mining industry in this region, especially if what he considers the right treatment of the ores is adopted. He is in favour of the "wet way," using sulphurous acid as a solvent. L. L. B.

THE COPPER-SULPHATE DEPOSIT OF COPAQUIRE, NORTHERN CHILE.

Eine Exkursion zur Kupfersulfat-Lagerstätte von Copaquire im nördlichen Chile. By HANS OEHMICHEN. *Zeitschrift für praktische Geologie*, 1902, *vol. x., pages* 147-151.

The author describes in some detail the general features and geology of the country as observed by him in a journey north-eastward from the Challacollo silver-mines (78 miles south-east from Iquique, as the crow flies), over the high dune-covered plateau of the Pampa Tamarugal, past Chelles, Tiquima and Huatacondo, to Copaquire, remarkable for its hitherto unique deposit of copper sulphate.

In the eruptive andesites and contiguous sedimentaries of Tiquima some exploration-work has been done on oxidic copper-ores. This occurrence is, as it were, the outpost, the first indication, of the cupriferous deposit farther within the mountains, which is presently to be described. Huatacondo is 3 miles or so farther up the glen than Tiquima, and 12 miles beyond that one comes to the granite-massif wherein the copper sulphate occurs.

This remarkable deposit had evidently been worked in olden times by the native Peruvians, but it was re-discovered only 4 years ago. Copaquire is about 10,500 feet above sea-level, and 44 miles east of Challacollo. The deposit is associated with the contact-zone between the granite and certain sedimentary rocks. Practically, all the rocks are impregnated with particles of copper-pyrites, but the eastern ridge of the Pastillo ravine (granite proper) is the most highly metalliferous. It is in decomposed belts of the granite too that the copper sulphate mostly occurs in magnificent dark-blue "stringers." Brown hæmatite and gypsum are commonly associated with the mineral, and less commonly malachite, azurite and chrysocolla. The talus below the ridges, consisting of débris largely impregnated or brecciated with copper sulphate, would of itself afford scope for profitable mining operations. Although rain very seldom falls at Copaquire, it does so sometimes, and thereby the uppermost layer of the débris is leached out and compacted into a sort of crust. Where the copper sulphate is in direct contact with the dry air, it loses, occasionally, its water of crystallization and crumbles into a white powder. The percentage of metallic copper varies between 2·5 and 3.

It seems that plans are being developed for working the Copaquire deposit on a large scale. As to the primary origin of the copper-ores, it is noticeable throughout this portion of the Province of Tarapaca that they are associated with acidic eruptive rocks. A more detailed study is promised for a subsequent occasion. L. L. B.

THE COPPER-ORES OF AMOLANAS, CHILE.

Das Kupfererzlager von Amolanas im Departement Copiapó (Chile). By A. ENDTER. *Zeitschrift für praktische Geologie*, 1902, *vol. x., pages* 293-297.

The mines of Amolanas rank among the most important in the department of Copiapó, and are situated about 15 miles south-east of the San Antonio railway-station (on the line from Caldera to the Pacific seaboard), at the upper end of a gorge, at a height of 7,216 feet above the ocean. The district is comprised within the southernmost portion of the great desert of Atacama, and 14 mining concessions have been pegged out in it, in strips 2¼ miles long and 820 feet broad.

The dark shales and quartzitic sandstones of the Lower Oolites and the Lias, astonishingly like the typical Jurassic of Southern Germany, are torn through, overlain by, or partly interbedded with dykes, sills, sheets and bosses of eruptive rock. Forming the ramparts of the Amolanas valley, two well-marked series of dykes strike east and west, parallel one with the other, about 3,000 feet apart: in the intervening space a complex of smaller dykes cuts through the Jurassic sedimentaries in various directions. The northernmost "rampart" consists mainly of a whitish liparite, which passes into a more distinctly porphyritic rock in depth. The liparite is full of irregular cavities which are in part infilled with copper-ore. This "rampart" of acidic rock is cut by sills of melaphyre and diabase-porphyrite, and associated with these, there are extremely coarse tuffs containing slaggy volcanic bombs.

The copper-ores occur chiefly in the form of impregnations, the general "habit" of which indicates that they crystallized out from mineral solutions circulating through the northern belt of quartz-porphyry, near the junction with the later basic intrusions. The last-named may therefore be regarded as the true ore-carriers, although on account of their own barrenness they are stigmatized as *caballos de piedra* (stone horses) by the miners. That the ores should occur over a length of only 1 mile, while the eruptive belt can be traced for several leagues, is attributable to a transverse disturbance and overthrusting, from north to south, fracturing the entire mass. The fissures thus formed were filled with metalliferous gangue, and caused an enrichment of the ores at those points where they traversed the ore-body.

The metalliferous particles were precipitated from the circulating solutions in the clefts and fissures and cavities, by the alkalies or alkaline earths contained in the rocks. These, with their alkalies thus leached out of them, became proportionately richer in silica and alumina, forming what is known in Chile as the *manto* (capel). The principal ores at Amolanas are dark leaden-grey copper-glance, red copper-ore (chiefly in compact or earthy masses at the outcrop), and blackish-green atacamite (in reniform, fibrous and compact masses). Of less frequent occurrence are malachite, chalcopyrite, bournonite, etc. In view of the fact that the ore as a whole is mainly an impregnation, the percentage of metallic copper in the deposit is low, ranging from 8 down to 5. Nevertheless the amount of copper in sight is reckoned at 1,215,000 tons. Working has been carried on, so far, in a terribly wasteful and unsystematic fashion. L. L. B.

THE AURIFEROUS DEPOSITS OF SURINAM OR DUTCH GUIANA.

Geologisch-bergmännische Skizzen aus Surinam. *By* G. C. Du Bois. 1901 [*published at Freiberg for the Maatschappij Suriname, of the Hague*], *pages i.-iv., 1-108, with 13 figures in the text, 2 plates of microscope-sections and a geological map.*

The geography, climate and geological structure of the colony are dealt with, and a short history is given of the comparatively recent development of gold-mining there. It would appear that the most important auriferous deposits are those of secondary origin, that is, the alluvial and other placers. "Reefs" have been proved at some places, but it is too early yet to say whether they would repay working: the true reefs or veins will be referred to later on.

Iron-ores, containing as much as 52·6 per cent. of metallic iron, are

associated with the laterites (rocks which are the result of the decomposition, under tropical climatic conditions, of diabases, diorites, etc.), but the cost of transport to the nearest available harbour is so enormous, that mining operations are at present out of the question. Another face would be put on the matter if railway-communication were provided. Copper-ores are said to occur, but the author has not seen them himself. The galena of the Carolina district is of no industrial importance. Concerning precious stones, only hearsay evidence as to diamonds is forthcoming, and the sapphires, zircons, garnets, etc., which the author has seen *in situ* do not call for special remark. There are widespread deposits of clays suitable for pottery purposes and of loams suitable for brickmaking. From this brief digression we return to the main subject of mining enterprise in Surinam, that is, gold.

The search for veins or reefs in the bush of Dutch Guiana is attended with unusual difficulty, as in most cases no outcrop or gossan or indicator of any kind is to be seen at the surface, and the prospector has usually to make trial-diggings in a happy-go-lucky fashion. The different complexes of "veins" are manifestly associated with the ancient eruptions of granites and diorites, and the richest of all occur in the old crystalline schists. All these rocks are much weathered, and both walls of the veins consist of an iron-stained, kaolinic, decomposed material. The older veins strike parallel to the schists and pitch steeply northward, while the newer strike north and south across the older, and pitch steeply eastward. The vein-stuff is quartz; this where richest in gold, assumes a reddish or a bluish-grey tinge, milky quartz being here a bad indicator. Iron-pyrites, tourmaline and iron-glance are frequent associates of the precious metal. The older veins average 3¼ feet in thickness, while the younger are only 10 to 12 inches thick. The native gold occurs in a very fine state of division, and also in large flakes among the cracks and crevices of the quartz. The pyrites, too, is auriferous, and the immediately neighbouring country-rock is often so richly impregnated with gold as to be worth working.

At depths of 100 and 165 feet below the surface, the greatest yet reached, pyritic ores seem to become more abundant; but the author is unable to say whether the conditions here are similar to those in British Guiana—that is, whether the auriferous veins have been more or less leached out near the outcrop, and become richer lower down.

Auriferous placers are distributed broadcast through Dutch Guiana: indeed, there is scarcely a single valley where gold cannot be said to occur, not only on the valley-bottom but on the hill-slopes also. The author shows how these placers originate primarily from the weathering, most often of "greenstones," less often of crystalline schists, granitic contact-rocks, etc., into laterite; and how the lateritic material deposited in the shape of clays, loams and gravels, forms the "eluvium" of the benches or deep placers, and the "alluvium" of the creek-bottoms or shallow placers. He does not consider, therefore, that the gold has travelled far from its original matrix; this is opposed to the popular local traditions in Surinam, which point to the still unexplored mountain-ranges, where Dutch territory marches with that of Brazil, as the *locus* of the auriferous rock. As a general rule, the alluvial placers are found to become richer as they are worked deeper down to the bed-rock, but in the eluvial placers or benches the deposit is richest some little distance above the bed-rock. The gold is of very fine quality, containing in 1,000 parts 926 of gold, about 50 of silver, and traces of copper; it is of a deep yellow colour. There is a so-

called "black gold," which will not amalgamate: the precious metal is covered by a deep black to brownish-red crust of iron oxide and organic matter. Ferruginous "greenstones" invariably occur in the immediate neighbourhood of the localities where this variety is found.

The author devotes a short chapter to hints on prospecting, and then gives a lengthy and well-illustrated description of the methods of working the placers. Great progress, in this matter, he says, has been achieved in Surinam within the last 15 years, although the greater number of placers are still worked on the primitive "long-tom" and wooden-sluice systems. But hydraulicking on a large scale with modern American plant has been started on several properties, and Government concessions have been obtained for the use of steam-dredgers in certain creeks.

The climate does not permit of the use of other manual labour than that of negroes or Indian coolies: the European soon breaks up under the strain, if he attempts to do hard physical work. In 1900, the gold-production of Dutch Guiana reached a total of 28,041 ounces troy. A bibliography of the colony appropriately terminates this useful little work.

L. L. B.

BITUMEN IN CUBA.

Bitumen in Cuba. *By* T. WAYLAND VAUGHAN. *The Engineering and Mining Journal* [*New York*], 1902, *vol. lxxiii., pages* 344-347, *with* 2 *illustrations in the text.*

The writer was one of the three geologists appointed at the request of Governor-General Wood to make a reconaissance of the island, and the data included in the account were obtained partly at first and partly at second-hand. The survey dealt with deposits in the provinces of Pinar del Rio, Habana, Matanzas, Santa Clara and Puerto Principe. Numerous deposits of greater or lesser value were examined.

From the descriptions it appears that all the deposits of asphalt about which specific information was obtained occur as veins, pockets, or exuding springs, usually in serpentine-rock, but occasionally in limestone. None of the material is now found in its original matrix, it having come into its present position from elsewhere, but it is not at present possible to state the original place of its occurrence.

As for the commercial value of the deposits, the bituminous substances, asphalt and mineral tar, occur from place to place in every province of Cuba. In some localities there is promise of fairly large quantities. Much of the material can be used in the manufacture of varnish and for insulating purposes, but the practicability of its use for other purposes is at present an undecided question. Apparently in the glance-pitch the proportion of asphaltene is too high to allow of those cementing qualities required for paving, roofing, or asphalt-cement. Some of the material possesses large amounts of petrolene, but the stability of its chemical combination is yet to be determined. It is suggested that the glance-pitches containing much asphaltene might be mixed with maltha containing much petrolene. In undertaking any commercial handling of these Cuban asphalts and maltha there should first be a careful examination to determine quantity, and if proved that a property possesses sufficient quantity, it should be chemically studied in order to determine the precise uses to which it can be put. These bituminous substances offer an inviting field to the capitalist, but it is suggested that anyone contemplating such an investment should proceed with the greatest care.

X. Y. Z.

AURIFEROUS DEPOSITS IN SOUTHERN HAYTI.

Beiträge zur Geologie Haïtis: V. Das La Selle Gebirge, die Cul-de-Sac Ebene und das Salzseengebiet. By L. GENTIL TIPPENHAUER. *Petermanns Mittheilungen*, 1901, *vol. xlvii., pages* 169-178, *and* 2 *plates.*

This paper, on the whole, deals with a district which is interesting from every other point of view but that of the metalliferous miner. It contains, among other information, a catalogue of the 42 earthquakes recorded at Port au Prince, the capital of the Haytian Republic, between September, 1890, and November 25th, 1900.

In the latter portion of the paper, however, we learn that the Gosseline river, which runs down to the Caribbean sea at Jacmel, is, for a stretch of about 4 miles below its confluence with the Mabial, full of auriferous sands. These are estimated, from an assay made in New York, to contain 3 parts of gold per million. It is said, moreover, that gold has been found in the river-bed lower down its course, below the point where it joins the Grande Rivière, and also in alluvium near Jacmel.

The author found that the doleritic basalt through which the Gosseline cuts its way itself contains 3 parts of gold per million. It is evidently distributed throughout the rock in a very finely divided condition, so finely divided that the particles are invisible to the unaided eye. On the other hand, as gold has been found in flakes of about ¼ inch in diameter, it would seem that there must be an outcrop somewhere in the district, of rocks still richer in gold than these basalts. Now on examining the auriferous river-sand under the microscope, the author discovered not only that each particle of gold was adherent to a fragment of reddish-violet quartz, but that wherever quartz of that colour came into view, so surely was gold to be found with it. The district where the violet quartz-reef must occur, if its outcrop is to be found at all, is a triangle of about 324 square miles, bounded on the south by the junction of the basalts with the Tertiary limestones, on the north by the watershed of the Selle mountain-range and on the west by the watershed between the Gosseline and the Grande Rivière. The basalt-dykes, with which quartzose rocks are apparently associated, will be easily distinguished from the superficial basalt-flows. The neighbourhood of the dykes is generally indicated by outcrops of nearly vertical shale, torn asunder and thrust aside by the eruptive magma. These shales evidently underlie the newer (?) Tertiary limestones and sandstones. The facilities of communication with the district, and the abundance of water-power available, would contribute greatly to the success of gold-mining enterprise, if it should turn out that a workable reef occurs there. L. L. B.

THE BROWN-COAL DEPOSITS OF MAÏSSADE, HAYTI.

Das Lignitlager von Maïssade und der Aufstieg zum Zentralplateau von Gonaïves von Norden aus. By L. GENTIL TIPPENHAUER. *Petermanns Mittheilungen*, 1901, *vol. xlvii., pages* 193-199, *with* 3 *figures in the text, and* 2 *plates.*

In the centre of Hayti, surrounded on every hand by limestone-mountains ranging from 3,500 to 5,000 feet in altitude, is a broad flattish tableland, some 1,500 feet or less above sea-level. The geological evidence shows that this area is a former bay of the older Tertiary sea, and that it rose by a slow process of elevation during Pliocene times, so slow that the beds in the centre of the basin have neither been faulted nor disturbed. It seems likely

enough that artesian borings will tap a reservoir of petroleum—the product of the dry distillation of the long-buried marine fauna of the ancient gulf. As it is, petroleum-springs are known to exist some distance to the south, near Azua, in the same geological formation.

It is in this plateau-region, 6¼ miles northwest of Maïssade, that the brown-coal belt occurs. From north-west to south-east the belt extends for more than 7 miles, with an average breadth of 3¼ miles; but, as new outcrops of coal are being continually discovered, its real extent is probably much greater than this. The seams are almost horizontal, dipping at an angle of about 5 degrees at the edges of the basin. The best seam, about 5 feet thick, occurs in no case at a greater depth than 30 feet below the surface. It well repays working, and the quantity of coal available from it is reckoned at 50,000,000 tons. The analyses of this coal gave the following results:—Moisture, 16·05 per cent.; volatile matter, 41·30 per cent.; fixed carbon, 22·65 per cent.; and ash, 20 per cent. Moreover, it was shown to contain 3·19 per cent. of sulphur. Its calorific power is reckoned at 3,829 calories; and 1 pound of coal is required to evaporate 7·128 pounds of water. In some localities this coal could be worked by opencast. There are other seams of varying quality and thickness (1½ to 10 feet): generally speaking, the reddish-brown inferior lignites occur in the upper portion of the group, and the black, lustrous, more compact coals in the lower. The strata among which these lie are highly fossiliferous sandstones and clays, and the author holds that the coal- and lignite-seams are the remains of the mangrove-clumps which covered the swamps bordering the old Tertiary sea. Near the Canots hills, the lignites are suddenly thrust up into a nearly vertical position, conformably with the rest of the strata thereabouts.

There is plenty of timber available for mining purposes, and it is calculated that patent fuel or briquettes made from the Maïssade coal could be delivered at the Haytian seaports at exactly half the price now paid there for American coal (that is, at $3·50 per ton instead of $7). The actual cost of production or output [at the pit-mouth] is reckoned at 3s. 9d. per ton.

L. L. B.

IRON-ORES IN MEXICO.

Los Criaderos de Fierro del Cerro de Mercado en Durango, y de la Hacienda de Vaquerías, Estado de Hidalgo. *By* M. F. Rangel, J. D. Villarello and E. Böse. *Boletin del Instituto geologico de México*, 1902, *No.* 16, *pages* 1-44, *with* 5 *figures in the text, and* 6 *plates.*

The first portion of this memoir deals with the extremely rich ore-deposits situated among the mountains which cover so large a portion of the State of Durango. The Cerro Mercado, a ridge about 1 mile long, and some 2 miles north of the city of Durango, is covered with blocks of hæmatite, leading at first sight to the supposition that the entire range is made up of the ore. In reality, the ore forms a sort of dyke in a great mass of rhyolite, but it is believed to extend to a considerable depth below the surface. Besides hæmatite, martite, specular iron-ore, and red ochre also occur here, but no magnetites properly so-called. Among the associated minerals are quartz, apatite (in great quantity) and topaz. An analysis of the best hæmatite yielded the following results:—Iron peroxide, 91·5 per cent.; silica, 2·5 per cent.; alumina, 0·6 per cent.; and moisture, 3 per cent. Lime and phosphorus were determined as present in the residues, but no

quantitative result is recorded as to these. More complete analyses, made in the United States and based on 27 different samples, show that the average yield of the Cerro de Mercado ore is 55·8 per cent. of metallic iron, and the average amount of phosphorus contained in it, 1·328 per cent. (or 2·379 parts in every 100 of metallic iron). Sulphur averages only 0·085 per cent. of the ore, and it is plain that the deposit does not represent an enormous mass of pyrites altered by subsequent oxidation into hæmatite, etc.

The second, and larger portion of the memoir deals with the iron-ores of Pleistocene age which crop out in certain *barrancas* or ravines in the Tulancingo district of the State of Hidalgo. The stratigraphy of this area comprises Lower Cretaceous shales and limestones (often much folded), Cenomanian limestones (also highly folded) much poorer in fossils than the underlying group, Tertiary eruptive rocks (rhyolites, labradorites and basalts) and breccias of volcanic materials, with rolled and waterworn fossil-remains (*Mastodon*, *Equus*, etc.). The rhyolite was erupted in late Miocene or early Pliocene times, and the breccias belong to two horizons, separated probably by a considerable interval of time. Quaternary deposits and recent alluvia overlie the basalt, etc. A so-called "lacustrine" deposit of lignite, overlying tuffs with badly-preserved plant-remains, occurs in the Arroyo de las Flores. The lignite is of no commercial value, either as to quality or quantity. The now moribund vulcanicity of the region is represented by the thermal springs of Arroyo Seco (depositing ferruginous concretions) and Acaseca.

The great upheaval of this part of Mexico must have taken place near the beginning of the Tertiary era, as no folding or faulting of any consequence is observable in rocks of later date than the Cretaceous.

The iron-ore deposits are of excellent quality, and the local economic conditions of the Tulancingo district are favourable; yet for 40 years past the mineral industry has been conducted there on a very small scale, and only the actual outcrops have been worked. The ore-bodies are intercalated between the older labradorite (foot-wall) and the later basalt (hanging-wall), and vary in thickness from 4 to 32 inches. On the whole, they may be described as great flattened lenticles, thinning out into almost imperceptibly tenuous layers. They occur at an altitude of about 6,000 feet above sea-level, dipping slightly westward, and occupy a belt which is at least 19 miles long and 1¼ miles broad. The labradorite-footwall is of a "spongy" texture, impregnated with limonite; between it and the ore-body intervenes a thin band of rhyolitic breccia, similarly impregnated with limonite and with semi-opal. The ore-deposit itself consists in its lower part of limonite, and in its upper of red hæmatite. Between this and the basaltic hanging-wall, there is a thin band of ferruginous semi-opal of various colours. The ore-deposit is very crumbly and therefore easily worked, the masses of hæmatite being bound together merely by a sort of argillaceous cement. A sample of limonite from the El Sabinal mine yielded the following analysis:—Iron peroxide, 75·72 per cent.; silica, 8·37 per cent.; combined water, 16 per cent.; and traces of phosphorus and lime.

The genesis of the deposits is discussed at considerable length, and the conclusion is arrived at that the iron was originally leached out of deep-lying rocks by carbonated thermal solutions at high pressure, and thus it came about that silicates of iron passed into soluble bicarbonates. These were precipitated (and subsequently oxidized), as the thermal waters lost some of their heat in their upward journey. L. L. B.

THE ORE-DEPOSITS OF TAXCO DE ALARCÓN, MEXICO.

Apuntes relativos al Mineral de Taxco de Alarcón, Estado de Guerrero. By LEOPOLDO SALAZAR. *Memorias de la Sociedad científica "Antonio Alzate,"* 1901, *vol. xvi., pages* 167-177, *and* 1 *plate.*

As early as the middle of the sixteenth century the Spanish *conquistadores* obtained from the neighbourhood of Taxco copper and tin, which they used for casting cannon. But the real wealth of the district was only revealed two centuries later by the enterprise of a French miner. He made money enough to build a magnificent church, and appears to have retired to enjoy his fortune in 1763. From that time onward until pretty late in the nineteenth century, various mines were opened up haphazard, and worked irregularly, the salient feature of the industry (such as it was) being the absence of scientific method.

Certain mining engineers, who examined the district, more or less officially, previous to 1884, conceived favourable views of its possibilities, pointing out that none of the workings had been carried to a depth exceeding 330 feet below the surface. The statistics published by the Mexican Government in 1892 and 1898 showed, however, that the attempts to revive the mineral industry at Taxco had met with but scant success. The present author is now engaged in exploration-work there, on behalf of a mining company, but he does not look for immediate results. So far, he has devoted special attention to the area south-east of the town of Taxco. He describes the andesitic eruptive rocks which he has found in contact with the metalliferous veins at a depth of 100 feet or so, and regards their presence as a favourable sign. It is supposed that the eruption of the andesites fissured the rocks of the district, and that the metalliferous ores were subsequently deposited in the fissures by hydrothermal action. As in many other of the mining districts of Mexico, a later period of eruption is denoted by the abundant occurrence of rhyolitic lavas which cap the summits of the mountains.

In the central portion of the district, that is, at Taxco and south of it, mining operations will have to be carried pretty deep down, in order to reach payable ore. The conditions for exploration-work are favourable, labour, pit-timber and fuel, being all within reach; but a fair amount of capital and patient plodding work will be necessary to make the mines pay. The author omits to say clearly what the ores are, apart from the copper and tin already mentioned, but one may infer that they are silver-ores.

L. L. B.

PEAT IN PERU.

La Turba en el Perú. By JOSÉ J. BRAVO. *Boletin del Ministerio de Fomento,* 1903, *No.* 1, *pages* 20-22.

Peat occupies the bottom of nearly all the valleys of glacial erosion in the high Cordilleras, in the centre and south of the country. It is a spongy mass of a yellowish colour, darkening to black deeper down. For local use, the peat is generally not cut at a greater depth than 8 or 12 inches, although the author has seen cuttings of 6½ and 10 feet. The peat is cut out in rectangular blocks and dried in the sun. In the pampas of Callan, in the province of Jauja, 12,600 feet and more above sea-level, there is an area exceeding 750,000 square metres (200 acres) covered by peat 10 feet or so thick, the analysis of which is as follows:—Fixed carbon, 27·5 per cent.,

volatile combustible matter, 36·7 per cent.; ash, 21·2 per cent.; and moisture, 14·5 per cent. The calorific power has been determined as equivalent to 5,021 calories, and this peat has been successfully used (when mixed with a little coal) for roasting ores in reverberatory furnaces.

A recapitulation is given of the turbaries and analysis of peat therefrom, mentioned by Dr. Raimondi in vol. iv. of his work on Peru; and the author then goes on to point out that, although the climatic conditions of the Pacific seaboard are not on the whole favourable to the formation of peat, some turbaries are to be found in the coastal region of Peru, such as those of Vientelo in the neighbourhood of Lima. Here the peat is of very recent formation; its analysis is as follows:—Fixed carbon, 11 per cent.; volatile combustible matter, 34 per cent.; ash, 29 per cent.; and hygroscopic water, 26 per cent. It is compressed into a kind of patent fuel, after preliminary dessication (to ⅓ of its weight) and impregnation with tar.

According to the mining laws of the country, peat-deposits belong to the owner of the soil. These deposits generally occur on pastoral land of small value, and in districts where labour is cheap. There appears to be an opening for peat-cutting on a grand scale, under advantageous conditions.

L. L. B.

THE MINERAL RESOURCES OF THE PROVINCE OF CAJATAMBO, PERU.

Memoria acerca de las Riquezas Minerales de la Provincia de Cajatambo, y especial de los Cerros de Chanca. By JUAN TORRICO Y MESA. *Anales de Construcciones Civiles, Minas e Industrias del Peru*, 1901, *series* 2, *vol. i.*, *No.* 2, *pages iii. and* 70.

The province here described covers an area of 5,838 square miles, and the population (largely half-breeds and Indians) probably does not exceed 40,000. On the east and north Cajatambo is bounded by the snow-clad summits of the Cordillera Blanca, etc., and the spurs coming down from these high Andes divide the region into innumerable glens and valleys. Despite the rugged nature of the country the roads are not so steeply graded as might be imagined; those, however, which run from the chief city to the Pacific seaboard are not merely bad, but positively dangerous.

Proceeding eastward from the harbours of Huacho and Supe towards the interior, one passes over great eruptive masses of syenite, granite and diorite, which farther inland are mantled by alluvial deposits and clays. Then come the younger eruptive or porphyrites, occupying a vast area: with them are genetically associated the silver-bearing veins. The porphyrites are followed by a great belt of sedimentaries, and the summits of the Cordillera Blanca are well nigh reached before another series of eruptives comes in (syenites). There are no recent volcanoes or any eruptive phenomena of modern date in Cajatambo, except indeed the sulphureous and ferruginous thermal springs of Churin, Viroc and Lacha.

The author's brief reference to the fossils found among the sedimentaries leads one to infer that these are largely of Jurassic age. He certainly thinks that the coal-bearing sandstones belong to that period, but he suggests that the marls (with brine-springs) of Oyón and Colpa are remnants of the Triassic formation. The two most abundant useful minerals in the province are silver-ores and coal: a rapid sketch of its other mineral resources will not, however, be deemed out of place.

Gold is known to have been mined both by the Spanish *conquistadores*, and before them by the natives. There are, however, no gold-workings in activity at the present day. The precious metal is associated, sometimes in fairly considerable proportions, with the silver of the argentiferous ores.

Silver, invariably associated with antimony, occurs abundantly all over the province, from the Pacific seaboard to the summits of the Cordillera Blanca; but it is noticeable that the ores increase in value and quantity as one approaches the main chain. In many instances, iron-pyrites is associated with these, and then indeed forms the principal infilling of the fissure-veins. In the veins the silver seems to be concentrated in rich "pockets," between which completely barren "ground" intervenes. The most common mineral species are tetrahedrite, bournonite and panabase, then less commonly occur pyrargyrite, stephanite and dürfeldtite (a comparatively new silver-antimony ore discovered for the first time in the Irismachay mine in this province). Frequent secondary associates are galena, blende, iron-pyrites, stibine, chalcopyrite, and in some cases azurite, malachite and chrysocolla. The gangue is most usually quartz or calcite, more rarely pyrolusite, dialogite and barytine. As in nearly all Peruvian ore-deposits, the minerals are very seldom in the crystalline form.

Going from south to north, the author describes in succession the silver-mines of Mesías, Mercedes (Uticto district), Nazareno, Anamaray (Quichas district), Raurac, Gasuna, Tarasca, Tinta, Auquimarca, Tallenga, etc. In some cases, calcination, lixiviation and amalgamation are carried out *in situ*, the furnaces being fired with Conocpata coal.

Copper is almost as frequent an associate of silver in Cajatambo as antimony, but cupriferous deposits properly so called are of comparatively sparse occurrence, so far as is at present known. The recent rise in price of the metal has, however, stimulated prospecting work in this direction.

Galena occurs in many mines, but in small quantity and irregularly distributed. It almost always contains some antimony. The only mine where the lead-ore may be regarded as of industrial importance is that of Niñoperdido, in the Raurac district: the deposit here contains as much as 70 per cent. of lead, and never as little as 40 per cent.

Blende, mostly associated with tetrahedrites, bournonites, etc., can hardly be said to form independent deposits.

Antimony-ores and iron-pyrites have already been mentioned.

Coal occurs all over the province in a great series of sandstones interstratified with thin shales, in seams which vary in thickness from 2 to more than 60 inches. The character and quality vary from anthracite to long-flame bituminous coal. The most important deposit is that of Conocpata. An Italian company, as many as 15 years ago, drove an adit here, and experimented on the coking quality of the coal with extremely satisfactory results. Both roof and floor of the seam consist of a lustrous black shale, difficult to distinguish at first sight from the coal itself. The thickness of the seam varies from 16 inches to 5 feet. The dip, nearly horizontal at the outcrop, increases gradually to 60 degrees. The coal is excellent for blast-furnace and reverberatory-furnace purposes, it leaves only about 4 per cent. of very white ash, and contains scarcely any earthy matter or pyrites. The Conocpata coal is of unique quality so far as the province of Cajatambo is concerned, no other exactly like it being found there.

In the Gasuna district, three seams are worked, with a sandstone-roof and a shaly floor. The thickness of the seams is fairly uniform, averaging

20 inches. The coal is crumbly, dusty, burns with a short non-crepitating flame, leaves extremely little ash, and is unsuitable for coking purposes. The author classifies it as an anthracite.

Around Oyón, there are many seams of coal of intermediate character, almost all the varieties which range between anthracite and highly bituminous coal occurring there.

Very pure graphite is got from Antisicuar in the district of Auquimarca. Deposits of gypsum and native sulphur have been found recently near Cajatambo City. The occurrence of brine-springs has already been mentioned.

Reviewing generally the prospects of the mineral industry in Cajatambo the author takes a distinctly hopeful view, but points out that the great difficulty which demands the serious attention of the Government is the scarcity of labour. This applies not only to one province, but to the whole of Peru. L. L. B.

THE METALLIFEROUS DEPOSITS AND COAL OF THE CERRO DE PASCO, PERU.

Asiento Mineral del Cerro de Pasco. *By* MICHEL FORT. *Anales de Construcciones Civiles, Minas e Industrias del Peru*, 1901, *series* 2, *vol. i.*, *No.* 1, *pages* 1-164.

This elaborate memoir, which may be regarded as embodying all the latest information in the possession of the Peruvian Government as to the important mineral region of the Cerro de Pasco, begins with the more or less obligatory and customary historical summary. Mining began there as far back as 1630, but one gathers that of late years the normal development of the industry has been checked by various causes, among which may be mentioned the heavy cost of unwatering the mines, and extravagant speculation in regard to concessions. A fairly detailed bibliography is given, and the author then deals with the topography, physiography, climate, flora and population of the district. He devotes very rightly considerable space to the question of means of communication and transport: this will be solved ere long by the projected railway from La Oroya, which appears to offer no insurmountable engineering difficulties.

The fourth chapter, wherein the author makes extensive use of the works and conclusions of previous writers on the subject, deals with the geology of the area. The rocks have been so greatly disturbed by the agencies which determined the "uprise of the metalliferous mass," that the geological structure is very complicated. Messrs. Raimondi and Hodges, however, have done much to unravel the tangled skein. Two groups of rocks are recognizable:—(1) The metamorphosed sedimentaries, consisting of calcareous conglomerates, limestones (of Cretaceous age), older grits and barren slates; and (2) eruptives—quartz-biotite-andesites, trachytes (Raimondi), and possibly diorites.

The metalliferous deposits are divided into:—(1) Superficial, that is, largely altered and decomposed; (2) intermediary deposits; and (3) deep-seated deposits. The first may be regarded as a vast ferruginous gossan, with locally respectable proportions of lead and copper, and traces of silver, zinc, etc. In the second are found sulphides of iron, copper and lead, occasionally argentiferous. Rich pockets are of sporadic occurrence, and the ores are occasionally oxidized or even reduced to native copper. Blende is not very common in this group. The third or deep-lying group comprises the unaltered sulphides, arsenides and antimonides of silver, bismuth, copper,

lead, iron, etc., the mere fringe of which has been touched by mining operations thus far. The genesis of these great metalliferous deposits is evidently connected with those volcanic phenomena, one manifestation of which was the eruption of the andesites. Vast fissures were torn in the sedimentary rocks, and were ultimately infilled with metalliferous precipitates from thermal (siliceous and other) waters welling up from below.

The fifth chapter deals with the main difficulty, which it is essential for mining enterprise in the Cerro de Pasco to overcome—the elimination of the underground waters. If deep-level working is to continue and extend, the construction of great drainage-galleries is imperative.

From the sixth chapter, we learn that the methods of working are of the most imperfect and primitive description, and no progress is being made towards a better system. The miners are exclusively natives (so-called Indians); the total number of claims in 1899 amounted to 546, of which 449 were nominally for silver-ores (but including copper), 12 for gold, 77 for coal, 3 for rock-salt, etc., and nominally only 5 for copper (that is, deep-level). No less than 117 *haciendas* for the treatment of the ores have been established in the various ravines of the Cerro. The author describes briefly the various methods of treatment, which appear to be of the old-fashioned order, and offer, as he says, no feature calling for especial notice.

With regard to coal, the number of concessions in 1900 had reached 174, covering an area of 2,500 square miles. The mineral varies in character from anthracite to highly bituminous coal, and some of the seams are more than 30 feet thick. A railway to convey the coal to a central smelting-works, which would treat all the ores got from the Cerro de Pasco metalliferous mines, is badly needed. For this, as for other things, the author believes that the necessary capital will be forthcoming, so soon as the Peruvian Government grants the necessary legal securities and facilities. Cerro de Pasco appears to have been too long the battle-ground of contending syndicates.

Appendices giving the results of silver-assays, copper-assays and coal-analyses, accompany the memoir. We may cite such coals as that from the Carmen mine, Yanahuanca, containing 45 per cent. of volatile matter, 35·4 per cent. of fixed carbon and 19·6 per cent. of ash; that from the Tucsi mine with only 22 per cent. of volatile matter, but 54 per cent. of fixed carbon and 24 per cent. of ash; or the long-flame coal of Yanacachi, with 49·5 per cent. of volatile matter, 33·3 per cent. of fixed carbon and 17·2 per cent. of ash, and a calorific power of 6,290 calories. L. L. B.

THE GOLOVIN BAY REGION OF NORTH-WESTERN ALASKA.

The Golovin Bay Region of North-western Alaska. By J. D. Lowry. *The Engineering and Mining Journal* [*New York*], 1901, *vol. lxxi., pages* 751-752.

While much has been written about Nome, very little has been said about the Golovin Bay region, lying from 50 to 75 miles northeast of the former, although mining operations have been carried on principally around Council City, now called Golovin City, for the last three or four seasons. The characteristics of the region as regards formation, topography, etc., are similar to those of the Nome country, except that the general elevation is much higher. There is the same surface-covering of tundra, with the underlying strata of gravel, boulders, etc. Bed-rock, principally mica-schist

and shales, is variously found from 1½ feet down. This, however, is held by many to be a false bedding, and the theory is advanced that true bed-rock will be found at greater depth. Gold-dust from this region assays from £3 11s. to £3 19s. (17 to 19 dollars) or more per ounce. A quantity brought down from Ophir Creek last autumn by the writer ran nearly £3 18s. (18·62 dollars) to the ounce at the United States Assay Office at Seattle, Washington.

X. Y. Z.

THE NITRATE-DEPOSITS OF CALIFORNIA.

Natronsalpeter in Californien. *By* DR. CARL OCHSENIUS. *Zeitschrift für praktische Geologie*, 1902, *vol. x., pages* 337-339.

The author points out that the increasingly widespread use of smokeless powder is causing the demand for Chile saltpetre to develop enormously. Mining-engineers reckon that the Chilian deposits, supposing that the consumption increases at the same rate as it has within the last ten years, will be able to satisfy the demand for good nitrate for another quarter of a century. Then, however, it will become necessary to work the poorer deposits, nowadays contemned, containing only from 5 to 20 per cent. of nitrate.

In the northern part of San Bernardino County, California, the newly discovered nitrate-fields are reckoned to contain 22,000,000 tons of workable mineral, lying in places 5 feet thick, of a quality equal to that of the Chilian saltpetre. The geological and physiographic conditions, in fact the whole natural environment of the Californian occurrence, are almost exactly parallel with those of Chile. The author draws attention, however, to the fact that California, although dry, is not so absolutely rainless a region as Northern Chile; and he has consequently some doubts as to the real wealth of the Californian nitrate beds, for sodium nitrate (as he remarks) is an extremely hygroscopic substance. Just now, it would hardly pay to work beds containing less than 30 per cent. of pure nitrate. L. L. B.

THUNDER MOUNTAIN, IDAHO.

Thunder Mountain, Idaho. *By* WM. E. L'HAME. *Mines and Minerals*, 1901, *vol. xxi., page* 558.

Although much is known concerning the mineral wealth of Idaho, there are portions practically unknown to the outside world. These lie almost in the central section of the state, and their retarded development is principally due to their inaccessibility and remoteness from transportation facilities. For 15 miles above its junction with the main river, the Middle Fork of Salmon river has carved its bed through solid rock, the work of ages; sheer drops of 1,000 feet are frequent, and the confining slopes rise from 2,000 to 3,000 feet higher. A few daring adventurers have braved the dangers of this rapid stream, and the fact that a pan of gravel can scarcely be picked along the stream without getting the "colour" suggests extensive belts of auriferous material above.

One of these deposits was discovered about 3 years ago: it is a veritable mountain of ore, whose estimated wealth throws the treasures of the Incas into the shade. The locality is now known as Thunder Mountain, and its elevation is 8,000 feet, occupying a central position among the headwaters of Marble, Holy Terror and Monumental creeks.

Thunder Mountain consists entirely of volcanic material. Mineralogically and structurally, it is strongly suggestive of the Cripple Creek region. The predominating rock is rhyolite of a whitish colour, with porphyritic development of sand in felspar and quartz-crystals, giving it the characteristics of liparite. The gold occurs in this material in native form, auriferous pyrite being found only sparingly, whilst magnetic iron, a constituent of most volcanic rocks, is almost entirely absent. X. Y. Z.

PETROLEUM AND NATURAL GAS IN KANSAS.

Petroleum and Natural Gas in Kansas. *By* ERASMUS HAWORTH. *The Engineering and Mining Journal* [*New York*], 1901, *vol. lxxii., pages* 327 *and* 397.

The area in Kansas, throughout which oil and gas have been found in greater or lesser quantities, covers about 8,500 square miles in the south-eastern part of the state. In the extreme southeastern corner, the sub-Carboniferous limestone comes to the surface. Along the southern line of the state, the limestone dips to the west about 20 feet and to the north-west from 4 to 8 feet to the mile, and constitutes a floor upon which the Coal-measure shales and limestones rest. The base of the Coal-measures is occupied with the Cherokee shales with interbedded sandstones, the whole aggregating a thickness of 450 to 500 feet. These shales are known to extend west and north as far as drilling has been done, and they probably reach much farther. The Cherokee shales are the principal producers, as all of the oil and the greater part of the gas comes from them. All the strong gas-wells obtain gas from a sandstone lying within the lower 200 feet of these shales. There is some doubt about the continuity of the sandstone from place to place, but present knowledge favours the opinion that the productive sandstone of any one locality is limited in extent, and that it is in reality a lenticular mass of sand which changes to shale in every direction, while some distance away a corresponding bed of sandstone is found at or near the same horizon.

The drilling of the gas or oil-wells is done by machinery similar to that used in Indiana, Ohio, Pennsylvania and West Virginia. But the general condition of the ground is quite different from that of Indiana and other fields. In a number of instances, drillers have come to Kansas from the Indiana fields assuming that all the casing required was a short length at the surface, and have got into difficulties by the wells caving in at 400 or 600 feet below the surface. Owing to the many soft shale-beds it is generally necessary to case the wells for more than half their depth, and sometimes for almost their entire depth. In this one respect, well-drilling in Kansas is more expensive than in Indiana or Ohio, but otherwise it is as cheap as anywhere in America.

Gas is used as the principal fuel and light-producer in 12 or 15 different cities and villages, besides being piped to many farm-houses throughout the gas-region. And, on account of the cheap and abundant fuel supplied by natural gas, a number of manufacturing enterprises have already been established in Kansas. The more extensive of these are zinc-smelters, brick-plants, and Portland-cement factories, and present indications are that at no distant date coal as a fuel will be entirely superseded by natural gas throughout southeastern Kansas. X. Y. Z.

ROCK-SALT IN LOUISIANA.

Louisiana Rock-salt—Avery's Island. *By* HAROLD A. TITCOMB. *The Engineering and Mining Journal* [*New York*], 1901, *vol. lxxii., page* 780, *with plan and section in the text.*

Ten miles southeast of New Iberia, Louisiana, rising abruptly from a flat expanse of marshland, is a remarkable hill covering an area of about 5 square miles and from 150 to 200 feet high. It is called Avery's Island or Petite Anse. The entire island is underlain by a deposit of rock-salt, pure and absolutely free from foreign matter, and of unknown depth. A bore-hole nearly 2,000 feet deep failed to pass through the salt. Mining was carried on for many years, but the workings got flooded through being operated too near the surface.

A new shaft, however, has now been sunk; for 40 feet down from the surface it has been close-cribbed and cemented, so as to ensure the exemption of the mine from water. The cage thereafter descends through 470 feet of solid salt, and no pumping whatever is required from the mine. The salt is mined by a simple room-and-pillar system, 50 per cent. being left in pillars to support the roof. Galleries, 30 feet high and 30 feet wide, are driven; thirty holes, each 9 feet deep, are bored per round; each 9 feet hole is drilled in from 4 to 6 minutes by a compressed-air drill; the thirty holes take an aggregate charge of 100 pounds of 40 per cent. dynamite; and 65 tons of salt are blasted at each round. The salt is then loaded into cars, each carrying 2½ tons; hauled to the shaft by mules, then hoisted, crushed, sized, sacked, and loaded on cars for shipment. The total cost of mining and crushing is about 1s. 8d. (40 cents) per ton. X. Y. Z.

THE TUNGSTEN-DEPOSITS OF OSCEOLA, NEVADA.

The Osceola, Nevada, Tungsten-deposits. *By* FRED D. SMITH. *The Engineering and Mining Journal* [*New York*], 1902, *vol. lxxiii., pages* 304-305, *with* 1 *illustration in the text.*

In December, 1901, the writer made a careful examination of the deposit and believes it to be worthy of a more detailed description. Compared with other visible supplies of tungsten-ore in the world, these mines are of extraordinary economic importance, as they are apparently capable of producing more tungsten mineral than any other mine known and more, perhaps, than all other mines combined. The prominent outcrops of veins of white quartz in the brownish-grey granite were noticed by the earliest prospectors, but the mineral was for long supposed to be "specular hæmatite." More observant prospectors did not determine the true character of the ore until 1889, and it was not until 1899-1900 that any systematic attempt was made to really explore the deposits.

The veins are in the foothills and lowest slope of the Snake mountains; for several thousand feet up the mountain-side the formation is granite, which is overlain by Cambrian quartzite. The latter rock forms the main ridge of the mountains to the top of Mount Wheeler, or of Davis Peak, which is directly above the deposits in question. The veins, of which there are five prominent ones, all occur in the granite, and plainly cut across the bedding of the granite. Talus has covered the veins in many places, but they are discernible for a total distance of 1,800 feet up the mountain side, which has a general slope of about 18 degrees. The hübnerite-vein, shown

in Mr. J. H. Marriott's tunnel, has a strike of north 70 degrees east, and a dip of 65 degrees north-westward. The walls are well defined, and part easily from the vein, the width of which varies from 18 to 36 inches, and averages 26 inches throughout the whole length of the tunnel.

The hübnerite occurs in the white quartz in variously sized crystals, many of which are 3 inches long, and plainly show the crystalline character. Massive specimens when broken show cleavage-planes 2 to 4 inches long and 1 to 3 inches wide. Much of the mineral, however, is in fine grains and in irregular bodies. The quartz is found in some cases entirely enclosing the hübnerite, whilst in other cases, apparently solid mineral specimens are found to enclose the quartz. This plainly shows that the two minerals were deposited simultaneously. The quartz is very solid, with practically no evidence of weathering. No oxidation-products are found. In one locality, a considerable amount of scheelite was found mixed with the hübnerite.

As far as studied, it appears that the mineralization of the vein has taken place across its whole width, although it often occurs in larger quantities on one wall than on the other. This concentration on the walls was found to change from side to side in short distances. It was also found that a concentration of the mineralization into so-called shoots had taken place. At the same time some mineral was found throughout the vein. These shoots are very prominent on the surface, as each shows an abundance of the hübnerite in massive form, owing to the high contrast in the colours of the hübnerite and the gangue. At a depth of 80 feet, at the face of the tunnel, it is reported that the mineral was found in as good a proportion as the surface-indications would suggest.

As far as examined, the ore is remarkably free from other minerals. All of the ore shipped has been either hand-sorted and cobbed, or concentrated by the crude methods outlined in the text. These ores carried an average of 68 per cent. of tungstic acid. From the ore as exposed in croppings and workings, it is the opinion of the writer that the whole vein matter, if carefully concentrated so as to save both the hübnerite and the scheelite, would produce 10 per cent. of mineral carrying 70 per cent. WO_3.

The mine appears to be singularly favoured with regard to accessibility, proximity to water for milling and power, and large quantities of wood for fuel and for timber. The nearest railroad point is Frisco, Utah, on the Oregon Short Line, a distance of 85 miles, over fairly good desert-roads.

X. Y. Z.

DISCOVERY OF PLATINUM IN WYOMING.

The Discovery of Platinum in Wyoming. *By* WILBUR C. KNIGHT. *The Engineering and Mining Journal* [*New York*], 1901, *vol. lxxii., page* 845.

The Rambler mine is located about 50 miles southwest of Laramie, in the Medicine Bow Mountains, Wyoming. At a depth of 70 feet, a huge vein of oxidized copper-ores was found, which made it possible to commence shipping ore immediately the strike was made. Below the oxidized ores, chalcosite and bornite were found, and, still deeper, covellite. The ores have varied considerably in value, but the blue ore has averaged about 30 per cent. of copper by the car-load. The vein occurs in a schistose formation, that is only a short distance from the Archæan granite.

A short time ago, the Denver assayers, while attempting to account for

the variation in the assay-value of the ores, discovered that platinum was present, and usually in paying quantities, more especially in the blue copper-ore. The discovery of platinum in a vein is a matter of extraordinary scientific interest, especially so when it appears to have a commercial aspect, and it is probable that this region may prove to be of great importance as a platinum-producer. The average of ten samples showed 0·259 ounce of platinum per ton of ore. The second lot of samples were car-samples of from 20 to 45 tons each, and the platinum averaged 0·8 ounce per ton. Another test was made on a sample of matte carrying 1·92 ounces of platinum per ton. X. Y. Z.

THE MINERAL RESOURCES OF VENEZUELA.

Escursioni geologiche al Venezuela. *By* E. CORTESE. *Bollettino della Società geologica Italiana*, 1901, *vol. xx., pages* 447-469.

This paper embodies the results of the observations made by the author during a recent stay, extending over two months, in the northern part of Venezuela. His collection of rock- and mineral-specimens has been handed over to the care of the Royal Geological Office at Rome.

Metalliferous Veins, etc.—A great many mining concessions have been granted by the Government, in the neighbourhood of Caracas and up to near La Guayra, for the purpose of working the metalliferous veins that seam the mica-schists. It is said that near Caracas copper-ores can be traced over an extent of 7 leagues, but the author saw nothing of this. Around La Guayra the concessions were obtained for working pyrites, galena, graphite, etc. The author only visited one of these, and found a deposit of iron-pyrites which he does not believe to be auriferous. As to the graphite which does really occur in the mica-schists near La Guayra, it is not in sufficient quantity to justify mining-operations. South of Carúpano, on the other hand, and in the west, are metalliferous veins which have been worked in the past, and may yet be actively worked again in the future. Thus, in the Ensenada Esmeralda, west of Carúpano, is an outcrop of malachite and azurite, which in depth passes into chalcopyrite: it occurs among diabasic greenstone-slates. In similar rocks, nearer Carúpano, on Guiria Bay, is a vein of blackish argillaceous matter which was analysed in New York with the following result:—Copper, 67 per cent. [?], silver 3·5 per cent., gold 0·05 per cent., and vanadium 0·008 per cent. More to the south-west, at Revilla, Juan Burro, etc., above Cariaquito and Muco, is an extremely rich hæmatite, more especially associated with crystalline limestones. It is fine-grained, occasionally very siliceous, elsewhere very pure and heavy, and passing into magnetite. Though the ore contains perhaps 65 per cent. or more of iron, the author does not consider that it would repay working, on account of the heavy cost of getting it down to the coast and put on board ship.

In the localities known as Carmen and El Encanto, above Cariaquito, galena occurs in compact masses and in stringers among crystalline limestones. The ore will prove valuable for its lead, rather than for silver, of which it contains only 0·4 per cent. The old mine of Gran Pobre seems to be still very rich in grey copper-ore. The author mentions some other occurrences of chalcopyrite and galena, to which, however, he is unable, at present, to attach any very great importance.

Coal-bearing Formations.—It is said that nearly 480 outcrops of coal occur among the Oligocene (or Miocene?) sandstones of the Barcelona-Naricual dis-

trict, but the author confined his attention to such seams as are sufficiently thick to be workable at a profit. Of these he saw six in the Naricual district, two in that of Capiricual, and one in that of Araquita. The strike of the beds is generally east-south-east and west-north-west or south-east and north-west, but the dip varies greatly. The outcrops of coal are visible only in the valleys or ravines, being masked on the hills, either by the luxuriant tropical vegetation or by more recent fluviatile deposits. The coal is hard, compact, with a bright conchoidal fracture, and analysis has yielded the following results:—Moisture, 1·25 per cent.; ash, 2·83 per cent.; volatile substances, 38·63 per cent.; and coke, 58·49 per cent. The calorific power is tabulated as 9,052 [calories], and, everything considered, we have here an excellent fuel.

At the Naricual mine, 130 feet above sea-level, No. 5 seam is being won: it is more than 6½ feet thick. Exploration-work is being done on No. 3 seam, which is not far from 10 feet thick; and at the time of the author's stay in that district another seam was struck, still thicker than the last-named. There are many other seams at Naricual, ranging between 1 and 6 feet in thickness. Dips vary between 35 degrees and 55 degrees south-westward. Still another seam, the Vena Simplicio, 8½ feet thick, dips 60 degrees south-south-westward.

In the neighbourhood of Capiricual, in various *quebradas* or gullies, seams from 3 to 7 feet thick crop out, some 250 feet above sea-level. The estimated area of the coal-field is 309 square miles. It is worked exclusively by an Italian company, which also controls the railway from the coal-field through Barcelona to Guanta, and the breakwater at the last-named port.

Coal-outcrops have also been traced in sandstones of the same age as those of Naricual, etc., near Puerto Cabello and south of Carúpano.

Solfataras and Thermal Springs.—These occur more especially south of Carúpano in the Chaguarama Valley; they well out from among Miocene sandstones, making great bare white scars amid the tropical greenery, and depositing very pure native sulphur. A concession has been obtained by a German company: the concessionaires have put down a magnificent plant, and constructed a cable-railway, 11 miles long, to the seaboard at Carúpano. However, careful and repeated study of the locality seems to have convinced the author that sulphur will only be obtained thence in comparatively small quantity; on the other hand, he has ascertained the occurrence of cinnabar, and it is possible that this may prove to be of industrial importance.

Asphalt and Petroleum.—Rich asphalt-lakes occur at Guanoco and Guariquèn, among the lagoons which end off the Gulf of Paria on the west, also near Putucual, etc.

At Manicuare, opposite Cumanà, and near La Salina de Araya, the author observed indications of natural gas and oil. In fact he is persuaded that petroleum occurs along a vast extent of the coast-line of the Gulf of Cáriaco, and that there are the makings of a great industry, once the strike of the petroleum-deposits has been followed up and mapped out. L. L. B.

THE IRON-ORE DEPOSITS OF NEW SOUTH WALES.

The Iron-ore Deposits of New South Wales. By J. B. Jaquet. *Memoirs of the Geological Survey of New South Wales*, 1901: *Geology, No.* 2, *pages* 1-186, *with numerous maps, sections and plates.*

The writer has made a careful survey of all the deposits of iron-ore within a reasonable distance of those centres which, by reason of their

proximity to supplies of coal and limestone, may be regarded as suitable localities for the establishment of smelting-works.

The writer examined nearly 200 deposits of iron-ore. Many of these were of dimensions too small to be of value to the ironmaster, but the most important, to the number of sixteen, are tabulated below, shewing the districts in which they occur, the description of ore that they contain, and the estimated quantities that they will yield.

District.	Description of Iron-ore.	Estimated Minimum Quantity of Ore.
		Tons.
Breadalbane	Brown ore and hæmatite ...	700,000
Cadia	Specular hæmatite, magnetite, and carbonate ore	39,000,000
Carcoar	Brown ore and hæmatite ...	3,000,000
Chalybeate Spring	Brown ore	1,510,000
Cowra	Magnetic	100,000
Goulburn	Brown	1,022,000
Gulgong	Magnetic	120,000
Mandurama and Woodstock ..	Brown	609,000
Marulan	Brown ore and hæmatite ...	40,000
Mudgee	Brown ore with manganese ...	150,000
Newbridge, Blayney and Orange	Brown and magnetic	150,000
Queanbeyan	Magnetic	1,000,000
Rylstone and Cudgegong ...	Brown	443,000
Wallerawang and Piper's Flat...	Brown	200,000
Williams and Waruah River District	Titaniferous magnetic ore ...	1,973,000
Wingello	Aluminous	3,000,000
	Total	53,017,000

X. Y. Z.

THE METALLIFEROUS ORES OF THE MENADO DISTRICT, DUTCH EAST INDIES.

(1) *Verslag omtrent de gedurende het jaar* 1899 *in de Residentie Menado gedreven geologisch-mijnbouwkundige Onderzoekingen en Mijnontginning. By* M. KOPERBERG. *Jaarboek van het Mijnwezen in Nederlandsch Oost-Indië*, 1900, *vol. xxix., pages* 30-50, *and* 4 *plates.*

(2) *Verslag van het geologisch en mijnbouwkundig Onderzoek in de Residentie Menado over het jaar* 1900. *By* M. KOPERBERG. *Jaarboek van het Mijnwezen in Nederlandsch Oost-Indië*, 1901, *vol. xxx., pages* 115-121.

In the Totok river-basin, andesites and andesite-conglomerates are overlain by the Miocene-Pliocene marine limestones, and at the point where the river saws through a gorge in the limestone, irregular "quartz"-masses are found with visible native gold. The productive workings are all above the 1,000 feet contour-line, and no "quartz" is found at the base of the limestone-wall. One is rather inclined to infer that the "quartz" is really a chert, formed by silicification of the limestone in past ages, and that the gold, originally associated with sulphidic ores, has been set free by the processes of weathering.

Reefs or veins of quartz with sulphidic ores occur in the andesites and andesite-conglomerates of several localities (Bolang Mongondo, Ranoiapo

river, etc.): these ores are chiefly pyrites, more or less auriferous, zinc-blende, and galena (generally containing some gold and silver). The two principal veins of Soemalata occur in an eruptive conglomerate, at first thought to be porphyrite, with a steep north-easterly dip. The gangue is quartz, and the ores are pyrites associated with magnetic and arsenical pyrites, and now and then blende. So too the principal vein of Dopallak courses through eruptive rock: it consists chiefly of iron and copper-pyrites, with galena and a little zinc-blende, in a gangue of brecciated quartz and "blanched" andesite.

Details are given of the prospecting and preliminary work done by various private companies, and the Soemalata, Paleleh and Totok mines are briefly described. From the Paleleh mines all ore containing more than 150 parts of gold per million is shipped to Europe, the remainder being treated in the colony. The Totok mines had 20 stamps at work at the time of writing. L. L. B.

THE DIAMANTIFEROUS DEPOSITS OF SOUTH-EASTERN (DUTCH) BORNEO.

Les Gisements diamantifères de la Région sud-est de l'Ile de Bornéo (Possessions Hollandaises). By — GASCUEL. *Annales des Mines*, 1901, *series* 9, *vol. xx., pages* 5-23, *and* 1 *plate.*

Diamantiferous deposits have been worked by the Malays for many centuries, at the two extremities of the southern coast of Borneo. Those around Landak, near Pontianak, the capital of the western district, were not visited by the author, so his paper deals exclusively with those of Martapoera, near Banjermasin, capital of the southern and eastern districts. This town is built on piles, amid the marshes which extend inland from the swampy coast, and it, as well as the country right up to Martapoera (19 miles farther inland) is often under water during the rainy season.

Martapoera is situated a little below the confluence of two small rivers, tha valleys of which, as well as their affluents, are diamond-bearing. From the miner's point of view, the most important area is covered by the 49,000 acres stretching north and south of the Banjoe-Irang river. On the east the diamantiferous gravels abut on the flanks of coal-bearing Eocene hills, while on the west they dip under the swamps that extend to the sea-coast, and no man can say where they end. Of all the prosperous and populous villages that formerly dotted this area, only one, Tjampaka (6 miles fron. Martapoera) has retained some sort of vitality.

The "pay-gravels" are only a few inches below the surface in the upper parts of the valleys, lower down they are 23 to 26 feet below, and on the borders of the swamps they have to be reached by pits as much as 82 feet deep. Moreover, the thickness of the gravels varies greatly, more especially near the upper ends of the valleys: in the lower, broader portions the average thickness is about 3 feet, and there too the continuity of the deposit is more regular. Perhaps the most variable factor of all is the tenour in diamonds, not only in regard to the number of precious stones per cubic yard, but also as to dimensions, lustre, colour, etc. The chief constituents of the gravel are white quartz-pebbles, often iron-stained: with these are a few porphyritic rocks, micaceous quartzites, shelly limestones, rolled flints, and semidecomposed granulites and pegmatites, but no basic igneous rocks. The whole is more or less bound together by stiff white clay

(evidently the decomposition-product of felspars) and a less compact yellow clay. The overlying deposits are clays which pass downward into sands, and these in turn pass into gravels which become coarser and coarser until they pass into the "pay-gravels," the quartz-pebbles of which vary in size from that of a billiard-ball to that of a man's head. The bed-rock is either a compact red clay or dark bluish-grey tough shales. In the upper parts of the valleys a conglomerate of highly-decomposed greenstone-pebbles sometimes comes next below the diamantiferous gravels, and is underlain by the red clay. Both this clay and the shales are of Eocene age, and form the main mass of the hills. Among the shales are intercalated bands of grit and seams of bituminous coal, some of which are workable. There has been no change in the general physiography of the district since the deposition of the diamantiferous gravels, and we may therefore infer that they are of Quaternary age. The author, in contradistinction to the late Mr. J. A. Hooze's view* that the matrix of the diamonds of Martapoera is to be sought among the crystalline schists at the heads of the valleys, holds that the mother-rock of these diamonds is a granulite or pegmatite.

The diamonds are very little rolled, and have generally a distinct crystalline form, the most frequent being the octahedron. They are usually tinged with yellow, but are sometimes water-clear, very rarely red or blue, and still more rarely black. The last-named are highly valued by the natives as amulets against bad luck. The stones are on the whole small in size, renowned for their lustre and purity, and generally considered harder than the Cape diamonds. It is, however, the Cape diamond that is mostly hawked about by the Arab traders in Borneo as being the Martapoera diamond. Among the associates of the diamond in the pay-gravels are native gold, platinum, corundum (generally blue) and rutile. The black sand which forms the abundant residue of the washings contains much magnetite, titanite and chrome-iron-ore.

The deposits have never been worked on what Europeans would consider a methodical and regular system. A description is given of the primitive manner in which the natives set to work—but, however primitive, it implies a considerable amount of industry, patience and skill. In the later seventies, the South African diamonds made their appearance on the local markets, and it may be said that the diamond-industry of Martapoera, moribund since 1886, is now a thing of the past: the annual output is barely 1,000 carats. L. L. B.

AURIFEROUS ORES OF NORTHERN CELEBES.

Ueber die Geologie der Umgegend von Sumalatta auf Nord-Celebes und über die dort vorkommenden goldführenden Erzgänge. *By* G. A. F. Molengraaff. *Zeitschrift für praktische Geologie*, 1902, *vol. x., pages* 249-257, *with* 4 *figures in the text.*

The gold-bearing coastal area of Northern Celebes is of a very mountainous character: along the whole length of it runs a mountain-range, the summits of which vary between 5,000 and 7,000 feet above sea-level, forming the main watershed of that region. In the neighbourhood of Soemalata, the district which forms the principal object of the present memoir, this mountain-range is about 6¼ miles distant from the northern

* *Jaarboek van het Mijnwezen in Nederlandsch Oost-Indië*, 1893, *vol. xxii., pages* 1-431, *and* 14 *plates.*

coast and attains its highest elevation, that portion of it being known as the Bolio-Hutu range. Parallel to it, and halfway between it and the sea, runs another mountainous ridge (which the author calls the Soemalata coastal range) with summits varying from 3,300 to 4,500 feet in altitude. The Bolio-Hutu mountains consist of a granitic core, in part mantled by highly metamorphosed bedded rocks. To these latter, the author has applied the name of the Dolokapa series, as their best exposures are seen about the headwaters of the Dolokapa river. They consist largely of crystalline schists and contact-rocks, thrust up on end and showing the fan-like disposition familiar in the Alps, the Himalaya, etc. Overlying them unconformably is the Wubudu eruptive breccia, which constitutes almost the entire coastal range, from Matinang to Kwandang bay. The Wubudu river, from its sources to the sea, flows exclusively through this formation, and the pebbles rolled along its bed are made up of the eruptive breccia alone. In places tuffs are intercalated among the breccias, frequently showing traces of subsequent silicification.

The author also describes a purely sedimentary conglomerate, the Obapi conglomerate, best seen on the farther side of the ridge, behind Bolontio, 6 miles or so west of Soemalata. There is reason to believe that this conglomerate is older than the eruptive breccias above mentioned, being possibly of early Tertiary or Upper Cretaceous age.

The Wubudu breccias are traversed by two systems of fissures, the older striking generally west 35 degrees north and east 35 degrees south, while the younger strikes due north and south. Nearly all the metalliferous veins so far discovered along the "Gold Coast" of Northern Celebes, are associated with the older system of fissures. It is curious that faults are extremely rare in them, and they are largely infilled with eruptive material. In the case of the best mineralized veins the gangue is a peculiar, very felspathic, easily-weathered diorite-porphyrite of andesitic character: the author terms it the Dopalak porphyrite, as having been first noted in the Dopalak vein of the Paleleh mine. Mineralization seems to have taken place in several ways: sometimes the ore-deposit is a true contact-formation between the Wubudu breccias or country-rock and the Dopalak porphyrite; sometimes the actual metalliferous vein is more or less split up in the gangue-rock, in which case the latter is always impregnated with ore. A gradual passage between the two modes of occurrence is also seen. There does not seem to be much doubt that the genesis of the ores is associated with the volcanic activity which caused the injection of the fissures with andesitic and porphyritic magmas. This injection was probably accompanied and followed by the upwelling of thermal waters carrying the metalliferous particles in solution, and these were ultimately precipitated in the fissures and combined into various compounds.

The conditions of weathering are such that, inland the metalliferous veins do not crop out at the surface, whereas along the coast the eruptive dykes which contain them stand out like walls, the salbands especially offering considerable resistance to the continual beating of the surf. The remnants of these dykes form nearly all the islets, reefs and rocky headlands which characterize the northern coast of Celebes. The Dopalak porphyrite, in consequence of its high percentage of felspar, weathers (even down to a considerable depth) to an easily-recognizable clay, of a pale bluish-grey, flecked with numerous white specks, and assuming a pink tinge only near the surface. This clay serves as a good "indicator" for mining prospectors.

One metalliferous vein was observed by the author in the Dolokapa series. It was 4 inches thick, and was infilled with beautifully transparent, very pure zinc-blende, associated with some pyrites and quartz. The Obapi conglomerate is traversed by numerous fissures which are in part mineralized and gold-bearing. In their general strike they coincide with the younger system of fissures previously mentioned: these sometimes fault the older system, and the author does not positively know of any case where they are metalliferous, although he thinks it possible that the Dunuki vein is to be reckoned among these later fissures.

The chief ore-bearing veins in the neighbourhood of Soemalata are then more particularly described: these are:—(1) The Parajava, some 5 inches thick, infilled with auriferous magnetic pyrites, and a very little quartz and calcite; (2) the Northern, of a maximum thickness of 12 inches, only the western portion so far proving profitable, infilled with auriferous sulphides: up to January 1st, 1902, 660 tons of ore had been got from this vein, containing 30 parts of gold per million; (3) the Southern, the most important of all, and the only one that has so far been worked to any considerable depth. It is characteristically lenticular, varying in thickness from 4 to 50 inches. The Wubudu breccia forms the hanging-wall, and the Dopalak porphyrite the foot-wall. The ore consists of the following minerals, in decreasing order of abundance: arsenical pyrites, iron-pyrites, magnetic pyrites, zinc-blende, galena and rarely copper-pyrites. All are more or less auriferous and argentiferous. There is very little quartz, and still less calcite, associated with the metallic sulphides. The average gold-content is 40 parts per million, and in the richer portions of the vein it attains a maximum of 400 parts per million, although the precious metal is invisible to the unaided eye. From the beginning of 1900 up to August 1st, 1901, some 5,500 tons of pure ore were got from this vein, yielding about 8,270 ounces of gold. The deepest level in the mine (recently driven) is 65 feet below the adit. (4) The Veta Nueva, discovered as lately as 1901, was proved for a length of little less than 1 mile. So far, only the ferruginous gossan has been touched, but iron-pyrites and arsenical pyrites are to be met with below, and the vein is known to consist of a series of lenticles intimately intermixed with the Dopalak porphyrite.

The ore from the Soemalata mine is roasted on the spot with a mixture of coke and coral-limestone, and a matte consisting of 74 per cent. of iron, 1 per cent. of copper, and 25 per cent. of sulphur is thus obtained. Its gold-content is 200 parts or more per million. If it contains less, it is broken up small and re-roasted. The slag that runs off from the smelting-furnace is found to be free from gold, and hence it is assumed that the process involves practically no waste. The good matte undergoes a second smelting with an additional amount of lead. The gold is thus concentrated into the lead up to about 1,400 parts per million, and this auriferous lead is thereupon shipped to Europe. L. L. B.

MAGNETITE-DEPOSITS IN LUZON, PHILIPPINE ISLANDS.

Ueber eine Magneteisenerzlagerstätte bei Paracale in Nord-Camarines auf Luzon. *By* F. RINNE. *Zeitschrift für praktische Geologie*, 1902, *vol. x., pages* 115-117, *with* 1 *figure in the text.*

In the course of a visit to the Philippines in 1900, the author was enabled to examine an iron-ore deposit in the province of Northern

Camarines, on the eastern coast of the island of Luzon. The locality is a forest-clad hill rising some 130 feet above the surrounding district of Paracale, a small Tagala township, very near the embouchure of the Malaguit in the Pacific Ocean. It may be noted in passing that along the banks of the Malaguit are frequent outcrops of white and yellowish quartz, with which are associated pyrites and gold, evidently the débris of considerable reefs.

The hill of Bato-balani, or the Living Stone, is littered with blocks, great and small, of magnetite, and at first sight impresses the observer with the erroneous idea that the entire hill-mass is magnetite. Exploration-work, however, has shown that the ore occurs here only as loose blocks strewn on the surface, or accumulated in heaps, but not forming solid rock. Diggings prove that the weathered laterite on which these blocks rest, passes deeper down into a dioritic eruptive rock, and it may be plausibly assumed that the magnetite, at one time or another, has been chemically separated out of the diorite-magma. The occurrence reminds the author of the genesis of similar deposits in the Urals, such as Gora Blagodat and Wissókaya Sopka. In the case of Bato-balani, the former existence of a limestone overlying the diorite was doubtless an important factor in the contact-metamorphic phenomena which resulted in the setting-free of magnetite. Similar blocks of iron-ore are numerous near Dagang, and on the way up the Taguntung Hill, in the aforesaid district of Paracale. L. L. B.

CUPRIFEROUS SANDS OF LUZON, PHILIPPINE ISLANDS.

Kupferreiche Sande im Malaguitgebiet bei Paracale, Luzon. By F. Rinne. *Zeitschrift für praktische Geologie*, 1901, *vol. ix., pages* 387-389.

Two deposits of cupriferous sand are worked by the Tagalas in the Malaguit river-basin, one of which occurs in the neighbourhood of the Bato-balani ("living stone") magnetite in the Submaquin Valley, and the other in the Calaburnay Valley.

The author washed samples of sand which he obtained from these deposits, and found native gold, more abundantly in the Submaquin than in the Calaburnay sand. As a matter of fact, gold occurs in the alluvia of all the affluents of the Malaguit. The copper occurs abundantly in grains not bigger than the head of a pin, and is very pure. Magnetite and iron-glance form the main mass of the heavy residue, zircon is found in numerous minute crystals, and iron-pyrites only occasionally.

The condition of the constituents of these cupriferous sands shows that they cannot have travelled very far from their original *locus*.

The Tagalas smelt the copper in shells, and it is sold in that form to Chinese and Tagala traders. L. L. B.

UPRIGHT FOSSIL TREES IN THE FALISOLLE COLLIERY, BELGIUM.

Un Gisement de Troncs d'Arbres-debout au Charbonnage de Falisolle. By X. Stainier. *Bulletin de la Société Belge de Géologie, de Paléontologie et d'Hydrologie*, 1902, *vol. xvi., Mémoires, pages* 69-76, *and* 2 *plates.*

The occurrence of upright boles or trunks of fossil trees is by no means common in the Belgian Coal-measures. Those just laid bare at Falisolle happen to occupy a position in a cross-cut that affords unusually favourable

opportunities for close investigation. At this colliery, the Lambiotte coal-seam, the lowest worked in the principal pits of the Namur coal-field, overlies a bed of extremely hard, highly quartzose, white or grey grit, some 22 or 23 feet thick. Sometimes there intervenes a clayey "floor" (at most 30 inches thick), with rootlets of *Stigmaria*, between the grit-bank and the coal-seam. Eastward the grit thins out, southward and westward it passes into an excessively hard quartzite. At Falisolle, the Lambiotte seam is contorted into no less than six folds, between the Gouffre and Carabinier faults. Above the seam, at an average distance of 13 feet, is a seamlet of coal. This at Arsimont and Ham-sur-Sambre, comes near enough the Lambiotte seam to be worked with it, and so too in the southern district of the Falisolle colliery. Going westward, the seamlet suddenly diverges widely from the main seam, and it was hereabouts that the upright tree-trunks were discovered, in the thickness of a bed of 28 feet. They are three in number, two of them quite destitute of the usual external carbonaceous crust, and apparently are now mere casts of hard, compact, grey shale.

The author concludes that they did not grow in place, but were drifted into their present position and silted up there. He points out that no great mass of roots extends from their bases into the rock-floor: there are merely a few isolated fragments of roots, evidently brought from afar. At the roof of the seamlet above described, not only in the Falisolle colliery, but in all those of the neighbourhood, there is an abundant fauna of marine fishes. The practically simultaneous existence of these and terrestrial vegetation in the same area would presuppose (in the author's opinion) changes of cataclysmic violence, for which there is not the slightest evidence. The upright position of the fossil trees does not affect the question. It is well known that drifted trees float with their roots downward, as the centre of gravity lies somewhere near the base, and this would be especially true of the conical, all but hollow, trunks of the Carboniferous forest-trees. L. L. B.

BAUMHAUERITE, A NEW SULPHARSENITE OF LEAD.

Bleisulfarsenite aus dem Binnenthal. Theil III. Baumhauerit, ein neues Mineral, und Dufrenoysit. By R. H. Solly. *Zeitschrift für Krystallographie und Mineralogie*, 1903, *vol. xxxvii., pages* 321-331, *and* 1 *plate.*

This new mineral has been found in the Binnenthal, Switzerland, in isolated monoclinic crystals, associated with other plumbosulpharsenites, in the white dolomite of the stream-bed of the Lengenbach. It is leaden-grey to steel-grey in colour, possesses a metallic lustre, and yields a chocolate-brown streak. The mineral exhibits conchoidal fracture, its hardness is 3, and specific gravity 5·33; and the chemical formula is given as $4PbS,3As_2S_3$. Sometimes the crystals are of tabular form, deceptively like those of jordanite; sometimes they are rhombic prisms like dufrenoysite; and some apparently simple crystals are really built up of sensibly parallel growths of small crystals, often twinned. The paper contains an elaborate description and crystallographic measurements of the various forms, and also the chemical analyses by means of which the above-cited formula was arrived at.

The mineral is named after Prof. Baumhauer, of Fribourg. L. L. B.

THE FLORA OF THE ALPINE UPPER CARBONIFEROUS.

Begleitworte zur Demonstration eines Florenbildes der Alpinen Obercarbon. By F. VON KERNER. *Verhandlungen der kaiserlich-königlichen geologischen Reichsanstalt*, 1902, *pages* 125-127.

The vegetation generally, of which the remains are preserved in the Carboniferous strata of the Alpine region, was one that grew along the banks of rivers which brought down in their waters mud, sand and gravel. At the Steinach Pass, in the Tyrol, remains of tree-ferns are predominant (*Pecopteris, Alethopteris, Scolecopteris*, etc.) and the creeping fern, *Lygodium Stachei*. The Sphenopterids, so characteristic of the Middle Carboniferous, are not to be found in the Upper Carboniferous of the Central Tyrol. Other well-known Coal-measure plants which occur in the fossil flora of the Steinach Pass are species of *Lepidodendron, Lepidophyllum*, and *Calamites*. L. L. B.

CALEDONITE FROM THE CHALLACALLO MINES, CHILE.

Ueber einen neuen Fundort des Caledonits in Chile. By GEORG BERG. *Tschermak's Mineralogische und Petrographische Mittheilungen*, 1901, *vol. xx., pages* 390-398.

This mineral is a sulphate and carbonate of lead and copper, in small blue crystals, and was found among the ore-specimens from the upper levels of the Challacallo silver-mines, in the Atacama desert. It forms part of a collection recently forwarded to the Freiberg Mining Academy.

The intense sky-blue coloration of the mineral differentiates it from nearly all previously-described occurrences of caledonite. The locality, moreover, is a new one for that mineral species. A chemical analysis of the Challacallo caledonite is given, showing its high percentage of carbonate and, after an elaborate discussion of the analyses of caledonite from other localities, the author rejects the view (advanced by Prof. Story-Maskelyne and Mr. Flight) that carbonate occurs in it merely in the form of a mechanical admixture of cerussite. Still, what with differences of coloration and chemical analyses, it would appear that caledonite can hardly be regarded as a mineral of fixed composition, and it is here defined as an "isomorphic mixture."

The Challacallo ores occur as parallel veins, sometimes coalescing into one great vein, coursing through a quartz-trachyte cone which rises up from the high plateau of Atacama. The strike is north, nothing to 10 degrees west, and the dip westerly, very steep. The filling of the veins appears to be chiefly quartz, but it is a question whether deeper down the quartz is not in part replaced by other minerals. There are cross-veins, dipping steeply too, but they appear to have little effect on the principal vein. On the other hand there is a great crush-zone, 6 to 13 feet thick, to which the rather vaguely-used term *manto* has been applied, which has had an impoverishing influence on the principal vein—owing perhaps to the circulation of subterranean waters, leaching out and carrying off the ore-particles.

Many rare minerals have been got from the outcrop, but the only immediate associate of caledonite here is azurite. The principal silver-content is connected with the so-called *lechedor*, a decomposed mass of vein-stuff and country-rock, highly impregnated with chlorides, iodides and other salts of silver. L. L. B.

CHALMERSITE, A NEW COPPER-SULPHIDE FROM BRAZIL.

Ueber Chalmersit, ein neues Sulfid der Kupferglanzgruppe von der Gold Mine "Morro Velho" in Minas Geraes, Brasilien. By E. HUSSAK. *Centralblatt für Mineralogie, Geologie und Palæontologie*, 1902, *vol. ii., pages* 69-72.

The gold-mine of Morro Velho, one of the oldest and most successful in Brazil, lies at the foot of the Serra do Curral, near the capital of the State of Minas Geraes. The ore-body, interbedded conformably with chloritic calc-schists, consists mainly of magnetic pyrites, carbonates, and arsenical pyrites, together with quartz. The strike is easterly and westerly, the dip about 45 degrees, and the depth to which workings have been carried well nigh 3,300 feet. There is no visible gold present in the free state: nevertheless the gold-content of the pyrites averages 18 parts per million.

After a reference to a detailed description of the mine,* the author draws attention to the druses lined with magnificent crystals of various minerals, which occur chiefly at the junction of the ore-body and the calc-schist.

The new mineral occurs invariably in such druses in association with the magnetic pyrites and the copper-pyrites, and has been described by the Prince Dom Pedro Augusto de Saxe-Coburg as millerite (which it is not).

It is strongly magnetic, has a specific gravity of 4·68, and corresponds to 3·5 in the scale of hardness. Called chalmersite after Mr. G. Chalmers, the superintendent of the mine, this mineral is found in opaque yellow acicular crystals, possessing a metallic lustre, often twinned. Chemical analysis yielded the following percentages:—Iron, 46·95; copper, 17·04; sulphur, 35·30; whence the formula $CuFe_3S_4$ (or $Cu_2SFe_6S_7$) is deduced. The author regards chalmersite as in all respects isomorphic with copper-glance; and a study of the order of crystallization of the minerals at Morro Velho shows that the new mineral was the last but one to separate out, being preceded by magnetic pyrites and followed by copper-pyrites. L. L. B.

RICKARDITE, A NEW TELLURIDE-MINERAL.

Rickardit, ein neues Mineral. By W. E. FORD. *Zeitschrift für Krystallographie*, 1903, *vol. xxxvii., pages* 609-610.

This mineral was found at the Good Hope mine, Vulcan, Colorado. The chief ore worked there is pyrites, with which metallic tellurium is associated in unusually large masses. The new mineral occurs in lenticles intimately intergrown with the native tellurium. The mean of two analyses shows its percentage-composition to be: Copper, 40·51; and tellurium, 59·49. This corresponds to the chemical formula Cu_4Te_3; it is a pure telluride of copper, without any traces of sulphur, selenium, arsenic, antimony, lead, silver or gold. As it constitutes a new type of telluride, the suggestion is put forth that each molecule of the substance is really a combination of one molecule of cuprous with two of cupric telluride, or $Cu_2Te + 2CuTe$. It has a magnificent purple colour, is tough, and of irregular fracture, of hardness 3·5, and specific gravity 7·54. When molten it burns with a pale azure-blue flame, green-tinged at the edges.

The mineral has been named after Mr. T. A. Rickard, of New York.

L. L. B.

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* *Engineering and Mining Journal* [*New York*], 1901, *vol. lxxii., pages* 485-489, *with* 5 *illustrations in the text.*

COLOURED TOURMALINES OF CALIFORNIA.

Precious Stones in the United States in 1901. By GEORGE F. KUNZ. *The Engineering and Mining Journal* [*New York*], 1902, *vol. lxxiii., page* 38.

Recent discoveries in Southern California have revealed a locality of coloured tourmalines, in a ledge of quartz and lepidolite, at an altitude of nearly 1 mile, on Mesa Grande mountain, San Diego County. As compared with the well-known locality of pink tourmalines in lepidolite at Palo, California, this new occurrence differs in presenting large and separate crystals in both lepidolite and quartz, many being translucent or even transparent, and with perfect terminations. Rubellite is the prevailing variety; but all the colours occur, sometimes several in one crystal—both in transverse sections, as at the Maine and Connecticut localities, and in concentric zones, as often in Brazil. Besides, there are some large and perfectly colourless achroites, and some yellow specimens. Frequently rubellite or other coloured crystals have a thin dark green, or nearly black, outer shell or coating, characteristic of this locality. Many gems have already been cut; and as specimens, the crystals are magnificent. A number of single rubellites, only partially perfect, weighing up to 70 carats each, and occasional yellow, green, and white gems, have also been found here.

X. Y. Z.

A NEW MANGANESE-IRON MINERAL, MANGANOSPHÆRITE.

Mittheilungen über Manganosphärit, Schwefel, Brookit, Augit und Pyrit. By K. BUSZ. *Neues Jahrbuch für Mineralogie, Geologie und Palæontologie*, 1901, *vol. ii., pages* 129-140, *with* 6 *figures in the text and* 1 *plate.*

At Horhausen in the Westerwald, Germany, the Luise mine is opened up in a spathic iron-ore deposit, which is associated with a basalt-dyke of a thickness varying from 2½ to 16 feet, cutting through the Devonian grauwacke-slates. At the 275 feet level the basalt is seen to be intrusive into the ore-body itself, inducing therein contact-metamorphic phenomena. Some of the cavities in the basalt are filled with reniform or grape-like aggregations of a mineral, the rhombohedral surfaces of which have a shimmering lustre. The colour is reddish-brown, much lighter than that of sphærosiderite. Careful microscopic examination and chemical analysis have proved that this is a new mineral, quite distinct from oligonite; and, on account of its high tenour in manganese, the author names it "manganosphærite." It stands in exactly the same relation to oligonite, as sphærosiderite does to spathic iron-ore. In the scale of hardness it stands a little below apatite, being represented by the number 4½ to 5; its specific gravity is 3·63; and its percentage-composition is as follows:—Ferrous oxide, 36·72, manganous oxide, 24·76; and carbon dioxide, 38·34. In other words, it is made up of three parts of iron carbonate to 2 parts of manganese carbonate.

L. L. B.

THE ARTIFICIAL REPRODUCTION OF MINERALS BY SUBLIMATION.

Ueber künstliche Darstellung von Mineralien durch Sublimation. By HERMANN TRAUBE. *Centralblatt für Mineralogie, Geologie und Palæontologie*, 1901, *vol. i., pages* 679-683.

It is pointed out that the reason why, up till recently, the method of sublimation in the experimental synthesis of minerals has not met with much

success, is that the boiling-points of most inorganic compounds are very high, and thus at the high temperatures at which the experiment must be conducted there is enormous difficulty in excluding either the oxidizing action of the atmosphere or the reducing action of flame-gases. Even the use of the vacuum-pump, though it allows of the lowering of the boiling-points, does not do away with the technical difficulties of such experiments. But the boiling-point of a given body, A, may be lowered by heating it with a substance, B, which sublimes at a lower temperature. It is thus, no doubt, that certain inorganic crystalline residues found in blast-furnaces originate—sublimation being facilitated by the presence of other vapours and gases.

Dr. Manross, in fusing amorphous [cerium] wolframate with sodium and potassium chlorides in a porcelain crucible at a temperature of 1,400° Cent. (2,552° Fahr.) had noticed that a portion of the "cerium wolframate" thus artificially reproduced had sublimed in beautiful crystals on the crucible-cover, and also on the outside at those points where the chloridic vapours had escaped. This led to further experiments on the volatilization of substances in the presence of sodium- and potassium-chloride vapour, for which purpose the author used an electric furnace patented by Dr. C. A. Timme. By measurement with a Le Chatelier pyrometer it was ascertained that the highest temperature attainable in this furnace is 1,500° Cent. (2,732° Fahr.): its principal advantage is that the reducing-action of flame-gases, etc., is completely excluded.

The following were the substances experimented with:—Cerium wolframate and molybdenate, didymium, lanthanum, calcium and lead wolframate and molybdenate, barium sulphate, and mixtures of the foregoing salts. Platinum-crucibles were used in some cases, porcelain-crucibles in others, and tubes closed at one end in yet others. At a temperature of about 2,552° Fahr., the potassium and sodium chlorides with which the wolframate or molybdenate was mixed vaporized abundantly, and sparkling crystals of the wolframate, etc., sublimed on the cover of the crucible or on the walls of the tube. Thus too were obtained crystals of barium sulphate and cerium wolframate combined, and also of pure barium sulphate. Without the presence of the chloridic vapours, it would be impossible to obtain crystals of these salts by sublimation.

The door is thus opened to further experimentation with many other mineral substances, and in this way light may be thrown on the genesis of many ore-deposits. Thus, for instance, the fact that scheelite may originate by sublimation tends to support Prof. Daubrée's hypothesis as to the genesis of zinc-ore deposits. L. L. B.

SECULAR VARIATION OF THE EARTH'S MAGNETISM.

Sur les Variations séculaires du Magnétisme Terrestre. By V. RAULIN. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences*, 1901, *vol. cxxxiii., pages* 760-763.

The author refers to a former paper of his, published by the Paris Academy in 1866, wherein he concluded that the hypothesis of a rotation of the magnetic north pole around the earth's pole in latitude 70 degrees, explained and co-ordinated all the facts so far observed in this connexion, in Europe and in the Atlantic basin. The rotation would last 600 years. He points out that the observations which have been accumulated, during the 35 years that have elapsed since his former paper, have fortified and confirmed his conclusions.

Declination at Paris increased from 1664 to 1814, decreased from 1814 to 1866, and will go on decreasing (*ex hypothesi*) till 1964. Then it would begin increasing again until 2114, decreasing thereafter till it returned to 0° in 2264. The decrease of declination has been just as regular since 1814 as was the increase in the 78 years preceding; and there is every reason to believe that the phenomenon will continue with the same regularity till the zero-point is reached in 1964. The present position of the magnetic north pole should be, according to the author, in longitude 141 degrees 7 minutes west [of Paris], somewhere beyond the mouth of the Mackenzie river.

Inclination has been decreasing for 230 years (since 1671) and it appears reasonable to assume that this will continue at least till 1964, thus completing a single decrescent phase of 300 years, parallel and simultaneous with the two phases (crescent and decrescent) of declination.

These phenomena are explicable, in the author's opinion, on the hypothesis of the existence of a fusiform magnetic body, probably ferruginous, the two extremities of which coincide with the earth's magnetic poles. The westerly displacement of the whole superficial magnetic system of the globe is explained, if we admit that this fusiform body and the liquid kernel of the earth travel less rapidly than the solid outer crust, in the diurnal east-to-west rotation, by an amount equal to $\frac{1}{360}$ of the velocity of that crust at all latitudes. L. L. B.

TERRESTRIAL MAGNETIC PULSATIONS.

Pulsations de la Force Magnétique Terrestre. By W. VAN BEMMELEN. *Archives Néerlandaises des Sciences exactes et naturelles*, 1901, *series* 2, *vol. vi.*, *pages* 382-384.

In studying the magnetograms of Batavia the author noticed series of pulsations of the horizontal component, evidently not due to solar disturbances, since they occurred for the most part during periods of magnetic calm. They took place during the night, and their amplitude was about $\frac{1}{10,000}$ of the horizontal component. The result of three years' study demonstrates that the mean period of these pulsations is subject to annual variations, from a minimum at the beginning of a year to a maximum in the middle of a year. Observations simultaneously made at Zikawei, near Shanghai, revealed series of magnetic pulsations, corresponding in amplitude and time with those recorded at Batavia, though on the whole the phenomenon is of less frequent occurrence at the former place. Other observations, carried out at Karang Sago, Sumatra, show a similar parallelism.

As to the immediate cause of such pulsations, it is pointed out that during solar perturbations, circular electric currents are developed in great number in the earth's atmosphere, inducing polar auroras. The nearer one approaches the zone of greatest auroral frequency, the more irregular are these currents; but in China and the Malay Archipelago they are more regular. In studying what he has termed "magnetic post-turbation" the author has satisfied himself that there is a system of electric currents travelling round the globe, parallel with the "isochasms" or curves of equal auroral frequency. It does not seem unlikely that the magnetic pulsations are caused by small and rapid periodic fluctuations in the aforesaid currents, and that such fluctuations are of terrestrial origin. They are perhaps comparable with the undulations of a fluid surface, which is being subjected to continuous disturbance at a particular point. L. L. B.

MAGNETIC ANOMALIES OBSERVED IN FRANCE.

Sur la Distribution Régulière de la Déclinaison et de l'Inclinaison magnétiques en France au 1er Janvier, 1896. By E. MATHIAS. *Archives Néerlandaises des Sciences exactes et naturelles*, 1901, *series* 2, *vol. vi., pages* 412-429; *and Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences*, 1901, *vol. cxxxiii., pages* 864-867.

The author had previously shown that the linear formula which gives, in functions of the geographical latitude and longitude, the law of regular distribution of the horizontal component for the region of Toulouse, is applicable to the whole of France.

He tabulates the results obtained (for declination) by means of a similar formula in 11 departments showing perfect regularity, and in 17 other departments showing on an average only one anomaly (with 5 or 6 observing-stations in each department). All the other departments (say 61) show variable proportions of regular and anomalous stations. On the whole, the measurements of magnetic declination at more than 300 stations in France and Corsica yield differences of less than 3 minutes 5 seconds, and it is evident that declination, although strongly influenced by local causes, even where the superficial strata of the earth's crust are not at all magnetic, conforms to a law of regular distribution just as much as the horizontal component does.

The author then attempted to trace the law of distribution of magnetic inclination. Here, by means of formulæ of the same order as that above mentioned, he found 462 stations yielding differences of less than 4 minutes. (In 16 departments there was no anomaly, in 17 only one.)

The final conclusion is that, for all the magnetic elements, only two departments are perfectly regular, namely, Ain and Hautes Alpes. The Loir-et-Cher, Mayenne and Sarthe, and also the Isère, are perfectly regular as regards the horizontal component and inclination, but anomalous as regards declination. In these cases it is argued that the irregularities of declination depend far more on the structure, than on the nature, of the underlying rocks. The structure indeed becomes an important factor, if we suppose that a part of the earth's magnetic field is due to telluric currents flowing in the neighbourhood of the earth's surface. It is then easy to account for the perfect regularity of the magnetic vector as contrasted with the anomalies of declination. L. L. B.

MAGNETIC DISTURBANCE OBSERVED AT ATHENS.

Sur une Perturbation magnétique, observée à Athènes le 8 Mai, 1902. *By* D. EGINITIS. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences*, 1902, *vol. cxxxiv., pages* 1425-1426.

On May 8th, 1902, from 1·35 a.m. until 9·30 a.m., at the very time of the destruction of St. Pierre in Martinique, a magnetic disturbance was recorded by the instruments set up in the Athens observatory.

It affected chiefly the horizontal component, the declination rather less, and the vertical component scarcely at all. The same phenomenon was observed simultaneously in Paris.

The author argues that if this perturbation was in fact one of the effects of the eruption of the Montagne Pelée, the originating cause must have been exclusively magnetic or electric, and did not consist in the mechanical trans-

mission of the earth-shocks which doubtless accompanied that great eruption. For the Agamennone seismograph at the Athens observatory remained absolutely motionless at that time, and yet it is an instrument which may be relied upon to record clearly even very feeble shocks. L. L. B.

PLUMBING DEEP SHAFTS.

(1) *Plumbing Deep Shafts of the Tamarack Mine.* *By* H. M. Lane. *Mines and Minerals*, 1902, *vol. xxii., pages* 247-248, *with* 3 *illustrations in the text.*

The No. 5 shaft of the Tamarack mine is the deepest shaft in the world, its depth being 4,938 feet. It was desired to connect this shaft with the workings from the No. 2 shaft, and a new survey was taken down both shafts. The shafts are 3,200 feet apart, and the proposed connecting tunnel starts at a point in No. 5 shaft situated 4,250 feet below the surface. The plumbing of No. 5 shaft was proceeded with, and No. 24 piano wire was used for the plumb-lines. The wires were lowered by a small engine, being weighted at their lower ends by wooden frames, or balloons, each 10 feet long, 2½ feet in diameter, and 20 pounds in weight. In the centre of each balloon a lantern was hung, so that the progress of the balloon could be watched from above and below. For obvious reasons, the balloons were lowered as nearly as possible in the centres of the shaft-compartments; but once lowered, it was desirable to place the plumb-lines as far apart as possible; 8 pounds plummets were substituted for the balloons, and the distance between the lines at the surface was increased to 17·58 feet. The 8 pounds plummets were then replaced by plummets of 50 pounds, when to everybody's surprise, the lines stretched a distance of 15 feet. The wires were then cut to the proper length, and the plummets were immersed in pails of engine-oil in order to minimize vibration. Here, again the unexpected happened, for the wires immediately shortened up 25 inches, owing to the buoyancy of the oil diminishing the effective weight of the plummets. But the greatest surprise occurred when it was found that the spacing of the plumb-lines was 0·07 foot or 0·84 inch greater at their lower than at their upper ends. Measurements above and below were re-made and verified, and the wires were examined throughout the whole length of the shaft, but nothing was discovered that could in any way account for the divergence. At No. 2 shaft, practically the same conditions were found, but the divergence of the lines was even greater, the spacing at the lower ends in this case being 0·1 foot or 1·2 inches greater than at the upper ends. The substitution of leaden for cast-iron plummets had no effect on the divergence, showing that magnetic attraction was not the cause of it. No satisfactory explanation of the occurrence appears to be as yet forthcoming.

(2) *The Divergence of long Plumb-lines at the Tamarack Mine.* *By* Prof. F. W. McNair. *The Engineering and Mining Journal* [*New York*], 1902, *vol. lxxiii., pages* 578-580, *with* 2 *illustrations in the text.*

Possible causes of the divergences have been offered and freely discussed. It was contended that the divergence was due to the greater attraction of the material at the end of the shaft for the plummet hanging nearest it. There seems to be a general lack of appreciation of the forces of gravitation. It is, of course, true that the attractions on each plummet towards the ends of the shaft differ, the stronger being toward the end nearest to which the plummet hangs. It is also true that these differences tend to diverge the

wires, but the amounts are so insignificant as to put them quite out of consideration. Another explanation worth notice was offered by Prof. Hallock, of Columbia University. This was that of mutual repulsion between like poles at the lower extremities of the wires. It was subsequently modified, so as to include also repulsion between like consequent poles distributed along the wires. However, the management of the Tamarack mine, with its characteristic interest in scientific matters, granted the writer permission to carry on further experiments in the shafts. These experiments are fully described by the writer, and the results seem to afford ample proof that neither gravitation nor magnetism could account for the divergence of the lines.

On the contrary, the writer became convinced that a very simple cause lay at the bottom of the divergence which attracted so much attention. One or both wires were deflected by the air-currents circulating in the shaft. This suggestion of air-currents was early made, but was at first treated with scant courtesy because it did not seem probable that such currents could be steady enough in speed and direction to permit the constancy of mean position which had been observed. But the hypothesis once admitted, it accounted for all the phenomena observed. Experiments showed that the divergence increased when the ventilation was augmented. The divergence diminished when wires of smaller section were used, that is to say, when the area of impact was diminished, and a thinner pencil of air collided with the wire. In No. 5 shaft, under normal conditions of ventilation, the divergence varied from 0·07 to 0·11 foot. The top of the shaft was then enclosed, but it was found impracticable to stop entirely the circulation of the air. But the reduced circulation of the air reduced the divergence to 0·018 foot. Again, in No. 2 shaft, which is a downcast, the plumb-lines diverged as in No. 5 shaft, while plumb-lines hung down No. 4 shaft, which is an upcast, converged in four experiments, the fifth showing a slight divergence of 0·004 foot.

The writer concludes by saying that it is remarkable that the air-currents should be so constant in their action. But the experiments have shown that the engineer who has to plumb a deep shaft has great difficulties to overcome, with regard to the influence of the air-currents on his lines. Before deciding where to hang his lines, and in order to estimate the dependence to be placed on them when hung, he should study the shaft air-currents very intently. X. Y. Z.

GOLD-MINING IN HUNGARY.

Die montangeologischen Verhältnisse des Kornaer und Bucsumer Thales, sowie des Goldbergbaues um die Berge Botes, Korabia und Vulkoj herum. By ALEXANDER GESELL. *Jahresbericht der königlich Ungarischen Geologischen Anstalt*, 1899, *pages* 97-103, *with* 1 *figure in the text.*

In the Korna valley, the Carpathian Sandstones and the underlying Jurassic limestones are the predominant rocks, but at some points they are interrupted by andesites, dacites and volcanic breccias. Mining industry flourished formerly in the upper part of the valley, but at present there is only one mine at work, the Valca Verde. The nature of the rocks does not appear to affect the metalliferous occurrences, as mines have been opened up indifferently in the igneous masses and in the sedimentary strata.

In the Bucsum valley, the Concordia mine works pillars of ore, associated with a conglomerate which is interbedded with sandstone. Workings are

pushed down to a depth of 280 feet from the surface, and the richest points are at the intersection of vertical with flat fissures. Native gold, in the free state, occurs in considerable quantity at such intersections. The infilling of the fissures here is calcspar and the country-rock is a siliceous breccia, believed to be of contact-metamorphic origin, resting upon slates: it too appears to be impregnated with gold. The author believes that gold-bearing rocks extend over a much larger area than that at present worked by the Concordia Company, and points to the fact that neighbouring mines are now also at work on flat auriferous fissures.

The core of the Korabia and Konczu range is made up of dacites and andesites, which in former ages burst through the Carpathian Sandstone Series. The fissure-veins in the eruptive rocks strike parallel with the mountain-range, and are equally productive in the (older) dacite and the (younger) andesite. Taken as a whole, the Botes-Vulkoi-Korabia ore-deposits are without doubt genetically connected with the famous Verespaták ore-deposit which seems to be their northward prolongation.

Cursorily glancing at the Arámа mine, the author describes more at length the Botes mine, worked by an adit in the hill of the same name. Here the auriferous belt, dipping northward some 20 to 30 degrees, is overlain by Carpathian Sandstone and underlain by shales. Instead of the pillar-like occurrences previously described, the ore-body here is more of the nature of a bedded mass 300 feet thick. The flat fissures, containing native gold in the free state, course parallel to the bedding-planes. The shales are absolutely barren, here as well as in the Korabia and Vulkoi mines. The Bucsum-Pojen and Valca-Csurtului mines are opened up in the eruptive dacites, and what was said of the Korna valley seems to hold good of the whole region traversed by the author, namely, the auriferous fissures are characteristic alike of the eruptive rocks and the sedimentary sandstones.

L. L. B.

THE ALSÓ-GALLA AND BÁNHIDA BROWN COAL-MINES, HUNGARY.

Der Alsó-Galla-Bánhidaer Braunkohlenbergbau der Ungarischen Allgemeinen Steinkohlenbergbau-gesellschaft. By LUDWIG LITSCHAUER. *Berg- und Hüttenmännisches Jahrbuch der k. k. Bergakademien zu Leoben und Přibram und der königlich Ungarischen Bergakademie zu Schemnitz*, 1902, *vol. l.*, *pages* 351-418, *and* 3 *plates*.

These mines belong, as indeed do many others in Hungary, to the Hungarian Universal Coal-mining Company, a powerful organization which, founded as recently as 1889, has extended of late years enormously its sphere of operations.

The deposits lie in a basin, bounded on the south-east, east and north-east by the Vertes hills (1,400 feet above sea-level), flattening westward down towards the Danube, and narrowing south-westward into the Mélyárok or deep gorge. The Danube hereabouts is 357 feet above sea-level, while Bánhida lies 145 feet higher, and Alsó-Galla and Felsó-Galla are situated at altitudes of respectively 522 and 662 feet.

The Tata Vidék (Alsó-Galla, etc.) concession stretches alongside the state railway-line, some 45 miles distant from Budapest and 119 miles distant from Vienna, a very advantageous position in regard to the Austro-Hungarian coal-markets. It covers an area of about 935 acres.

Proceeding to consider the geology of the so-called "Tata coal-field,"

which includes the three principal localities above mentioned, the author points out that the literature of the subject is very meagre. It appears probable that this coal-field is a continuation of that of Gran (Esztergom), and is possibly also to be correlated with the coal-basin of Pilis-St. Iván. The basement-rocks of the whole area are Triassic dolomites and Rhætic and Liassic limestones. Overlying these are Lower Eocene freshwater beds with coal-seams, succeeded by a brackish-water, and that in turn by a marine facies; next come Oligocene beds, in part also coal-bearing, and the whole complex is mantled over by æolian drift or lœss.

The coal is of excellent quality for a brown coal, and its calorific value nearly approaches that of ordinary (black) coal. It is pitch-black, with a conchoidal fracture and a greasy lustre, but crumbles too easily to furnish much round coal. A series of analyses, made during the years 1897, 1899 and 1900, yielded the following averages:—Combined water, 12 per cent.; ash, 7·5 per cent.; sulphur, 1·3 per cent. The heating power was 5,000 to 6,000 calories. In making briquette-fuel from this, petroleum-residues are used as a binding-material.

Coal is wound from three shafts, a fourth is in process of sinking, and there are also opencast workings. The average thickness of the seam is 33 feet, but this apparently includes some shaly partings. It is estimated that there are at least 72,000,000 tons of coal in sight, though it is expected that further exploration-work will show the true coal-reserve to be far greater than this. Previous to 1897, only one shaft had been sunk in this coal-field. Now, there is a central station furnishing electricity for transmission of power and for lighting to the three principal pits, endless-rope haulage is used on the inclined planes, etc., and the coal is loaded direct from the central picking-screens into railway-wagons by which it is conveyed to the Bánhida station of the Hungarian State Railway. Opencast workings were only seriously started in 1901: here, traces of Roman buildings and graves were discovered, but no signs whatever of ancient mining operations of any kind.

For shot-firing, progressite is the explosive used, with electric detonators. For ventilation of the pits Pelzer fans have been chosen, which pass 88,275 cubic feet of air per minute into the workings. Moreover, Munk and Capell reserve-fans have been erected. As the mines are fiery, Wolf benzine safety-lamps are used at the working-face, but the winding-shafts, inclined planes, etc., are lighted (as above mentioned) by electricity. The author enters into great detail regarding workmen's dwellings, clubs, schools and wages, and describes very fully the methods of working and the machinery in use at these collieries. L. L. B.

THE PETROLEUM-INDUSTRY OF AUSTRIA-HUNGARY.

Die Erdöl-industrie in Oesterreich-Ungarn. *By* EDUARD WINDAKIEWICZ. *Berg- und Hüttenmännisches Jahrbuch der k. k. Bergakademien zu Leoben und Přibram und der königlich Ungarischen Bergakademie zu Schemnitz*, 1901, *vol. xlix., pages* 17-104, *with* 8 *figures in the text, and* 2 *plates.*

This elaborate memoir is divided into thirteen chapters, the first of which is devoted to a brief history of the rise and progress of the oil-industry in the various territories of the Austrian Empire. Galicia saw its birth between 1810 and 1817, but the true beginning of it on a scale of any commercial importance dates from about 1859. It has been revived recently in the

Bukowina, and is making steady progress in Hungary. Despite the severity of American and Russian competition, Galician petroleum still holds its own, in the home-market at least.

Turning then to the geology of the subject, the author remarks that the structure of the Galician Carpathians constitutes a very thorny and complicated problem, which has been studied by a long succession of eminent scientific men, but no solution as yet proposed has been accepted unanimously as satisfactory. The Government geological-survey map of the petroleum-region of the Carpathians is now out of date; the geological atlas of Galicia begun in 1888 by the Provincial Government and the Cracow Academy of Sciences is not yet completed, and is moreover too full of local detail to facilitate a general view of the subject. Prof. Zuber, of Lemberg, however, has recently issued a most valuable map of the petroleum-region of Galicia, with explanations.

The petroleum of that province is intimately associated with the Carpathian Sandstone Series, a succession of alternating sandstones, conglomerates, shales, clays and marls. The want of characteristic fossils has long been a stumbling-block in the path of classification, but it is now pretty well ascertained that this series belongs in part to the Cretaceous, and in part to the Tertiary system. The various strata among which petroleum is most frequently found in Galicia are described, and the structural difference between the Carpathians of the western and those of the eastern district is emphasized. Thus, west of Stwiaz and San, the mountain-ranges are comparatively short, and consist mainly of uplifted and irregularly-contorted Oligocene and Eocene beds, among which now and then crop up (unconformably or pseudoconformably) the broken and disturbed Ropianka beds, of Cretaceous age. Eastward this unconformity dies out, and all the strata from the Ropianka beds up to the Oligocene, follow each other in conformable and parallel succession, forming a series of regular folds often interrupted by longitudinal faults. Practical experience has proved that petroleum occurs in greatest abundance where the strata are folded into saddles, and further that it occurs only in certain definite groups of beds.

The reservoirs of natural oil in the Cretaceous Ropianka beds are not of very considerable extent: in Western Galicia the best localities are those where there is a cover of impervious Eocene clays and shales. The limits of the rich Eocene oil-belt in the Eastern Carpathians are determined by the outcrop of the Jamna Sandstone (Cretaceous). In the Oligocene beds only those occurrences of petroleum are of industrial value, where the strata form broad, flattish, regular saddles. Where traces of oil are discovered in saddles of menilite-shale, there is always a prospect of striking the richer oil-reservoirs of the underlying Eocene by means of deep borings.

There appears also to be a great accumulation of petroleum and ozokerite among the saddles of the Miocene saliferous clays. A general rule is stated for all petroleum-deposits in the Carpathians, namely, that the south-western side of the outcrops is more regularly bedded, and therefore easier to work, than the usually dislocated and sunken north-western side.

In the Bukowina, the oil-belt ranges north-west and south-east in prolongation of the Galician oil-region, and is traced along three parallel lines. The central or second line is the richest, it yields oil (comparable with that of Galicia) occurring in the Oligocene portion of the Carpathian Sandstone Series. Not much has been done, so far, in the way of putting down bore-

holes or trial-shafts in the Bukowina, but a French company is said to have started operations recently.

In Moravia, petroleum has been found at a few localities, most recently of all at Göding. It occurs in beds which are correlated with the Miocene saliferous clays of Boryslaw.

Although petroleum has been found at several localities in Northern and Southern Hungary and Croatia, an oil-field comparable with the Galician is not to be looked for, so far as extent is concerned; but in regard to quality, the petroleum seems likely to prove equal to the best that is got in Galicia. As in that province, it occurs alike in strata of Cretaceous, Eocene, Oligocene and Miocene age.

Natural gas is of frequent occurrence in the strata overlying the petroleum-deposits, and is used at many localities for purposes of illumination. The author publishes the following percentage-analysis of the gas which burst forth at a pressure of 20 atmospheres from the Turoszówka boring, Krosno district:—Carbon dioxide 0·4, oxygen 0·6, ethylene 1·1, methane 82·3 and nitrogen 14·4.

Brine occurs in association with the petroleum in several localities, but as a rule in very small proportions.

The sixth chapter describes the physical and chemical characters of petroleum, and contains a very full comparative table giving the results of the distillation and fractionation of the crude oils of Galicia, Sumatra, Baku, Alsace and Pennsylvania.

The seventh chapter deals with the methods of winning, which have undergone a great change within the last 15 years, owing to the introduction of Canadian derricks and simpler pumping-plant. The various derricks and boring apparatus now in use are described and figured. In 1897, there were 571 shafts and 2,223 boreholes in the Galician oil-field; of these, 26 shafts and 1,263 bore-holes were yielding oil, and 21 shafts and 264 bore-holes were in process of sinking. There were 65 mineral-oil refineries in Austria and 16 in Hungary.

According to the Galician Naphtha Act of 1884, petroleum, ozokerite and bitumen are the property of the landowner on whose estate they occur. He may divest himself [in favour of others] of the right to win these products, a declaration being made before the mining authority, and the property being then entered as a naphtha-field in the official register. If the workings are continuously neglected in such wise as to be prejudicial to the common weal and common safety, the authorities may lay an embargo on the field, estimate its value, and sell it by auction. Such works as are necessary for the safety of mining operations may be extended even into neighbouring properties, with the obligation to make good any damage caused thereby. The authorities must receive four weeks' notice of the commencement of operations, and these can only be conducted by persons of certified capacity, duly confirmed by the authorities.

Statistics of output are given, whereby it is seen that Austria-Hungary in 1897 produced about 2 per cent. of the total amount of petroleum got from all countries, Russia and the United States accounting each for about 47 per cent. As a consumer of petroleum, Austria ranks next to Great Britain. Statistics of import and export are also given, and bear out the statement previously made that the Galician petroleum retains well its hold on the home markets. The memoir terminates with a list of all the petroleum-wells in Galicia and the Bukowina. L. L. B.

IRON-ORE MINES IN MORAVIA.

Die Eisenerzvorkommen und die ehemalige Eisenerzeugung bei Römerstadt in Mähren. By JOSEF LOWAG. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1901, *vol. xlix., pages* 129-133.

Little is known of the original working of the iron-ore mines at Römerstadt in Moravia. The earliest name of the town was Raymerstadt, and the Romans, probably, never penetrated to this district. The mines are, however, very old, and seem to have been worked by the Celts long before the Romans, for there are remains of open diggings and trenches far below the present surface. The iron was extracted from the ore in charcoal-furnaces, and this method was practised till quite recently. Mines of gold, silver, copper, lead and iron are mentioned in 1535. The mines were repeatedly pledged by the Crown to various people; and they are now the property of Count Harrach. The introduction of railways gave the death-blow to the charcoal-iron industry and although there were still stores of iron-ore in hand, the charcoal-furnaces were blown out everywhere. Even at the present day, immense quantities of good iron-ore exist in this formerly busy mining district, and await the enterprise of some ironmaster, who will be able to utilize them.

The ore is composed of brown, red, and magnetic ironstone. It occurs in several parallel beds in Lower Devonian chlorite-schists, and was chiefly dug from two places about 650 feet apart. The zone in which the ore is found is about 3,600 feet wide, and about 7 miles in length. The seams are from 3 to 18 feet thick and the percentage of iron varies from 30 to 60. If magnetic and red iron-ore occur in the same seam, the former is usually found on the floor, and the latter on the roof. The magnetic iron-ore is black and coarse-grained, generally rich in iron and contains much lime; the red iron-ore is usually iron-grey, siliceous, and contains red hæmatite. Where the three ores are found mixed, the percentage of iron in them is sometimes as high as 62. In some places the ore crops out at the surface, and fine crystals of iron-pyrites are often found in it. The seams are sharply defined, and are supposed to have been formed at the same period as the chlorite-schist. Three mines showed seams of magnetic iron-ore from 3 to 6 feet thick, and containing from 30 to 50 per cent. iron, reached by shafts 50 to 60 feet deep. In two others, the seams were about 80 feet below the surface, 9 to 18 feet thick, and the mixture of magnetic and red iron-ore contained 45 to 62 per cent. of iron. Another important mine had three shafts and one gallery at a depth of 328 feet; the seam was 19 feet thick, and the ore contained from 45 to 60 per cent. of iron. Many of the outcrops are untouched. The mines have at present been so poorly worked, and carried so little below the surface, that they might probably be driven much deeper, with good results. E. M. D.

GOLD-MINES IN THE HOHENBERG AND OELBERG HILLS, AUSTRIAN SILESIA.

Die Goldvorkommen am Hohenberg und Oelberg bei Würbenthal und Engelsberg in Oesterreichisch-Schlesien. By JOSEF LOWAG. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1901, *vol. xlix., pages* 415-417.

Nothing is known of mining for gold in the Hohenberg and Oelberg hills, near Würbenthal and Engelsberg in Austrian Silesia, until 1556. In

1828 an old shaft was re-opened and a quartz-vein containing gold and galena was found. In 1884, open cuttings were made in the Hohenberg and the Oelberg, and various further attempts to find gold proved fruitless. In 1893, the writer succeeded in discovering a vein of auriferous quartz, 6½ feet thick. A shaft was sunk and galleries driven, and 9 tons of quartz taken from it, yielded 17 dwts. of gold to the ton of ore. Later finds have given as much as 23 dwts. and 1 oz. 16 dwts. respectively.

The Hohenberg and the Oelberg, which are separated by a slight depression, form a contorted fold of Lower Devonian strata. The ridge is about 3 miles long, with a steep fall to the northwest. It consists of black or grey clay-slate, interspersed with quartz and mica, which impart a metallic glitter to the surface. The lode of auriferous quartz is embedded in the clay-slate, which also contains dark green chlorite-schist with magnetic iron-ore, quartzose schist with copper- and iron-pyrites, and masses of diorite. The Lower Devonian rests upon Laurentian gneiss. The fissures filled with auriferous quartz were probably formed during the folding of the strata and run parallel to the longitudinal axis of the folds. Long parallel depressions, eleven of which may be distinguished, denote the presence and the direction of the veins, which are thickest at the surface, and thin out as they descend to a depth of several hundred feet. The vein-quartz is coloured brownish-yellow with oxide of iron, it contains pockets filled with brown iron-ore, pyrites and galena, and is generally gold bearing. The more fissured the lode, the richer is it in gold; and the firmer and more compact the rock, the less gold does it appear to contain. To follow the vein, a perpendicular shaft was sunk for 40 feet, the quartz then again became solid, and the proportion of gold fell to 3 to 7 dwts. per ton.

Only these rich lodes were formerly worked, the poorer parts of the vein being left as supports. They were reached by sinking shafts, from 60 to 80 feet deep, below which the old miners could not go. At least 400 depressions have been counted, due to the filling up of these old shafts.

The auriferous zone lies in a valley, bounded by a copper-lode apparently of older formation, containing pyrites, malachite, a little gold, and the remains of old workings. The works at present consist of a shaft 46 feet deep; a gallery 984 feet long, at a depth of about 200 feet; a second gallery of the same length, and a shaft 65 feet deep. All the streams running from the Hohenberg and the Oelberg contain gold, which was formerly extracted by washing, and it is also found in the alluvial deposits forming the ancient bed of the river Oppa. E. M. D.

COPPER-MINING NEAR KNITTELFELD IN STYRIA.

Der Kiesbergbau der Flatschach und des Feistritzgrabens bei Knittelfeld in Steiermark. By Dr. Karl A. Redlich. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1901, *vol. xlix., pages* 639-643, *and* 1 *plate.*

From the beginning of the eighteenth century copper has been mined in the Flatschach, a district north of Knittelfeld in Styria, by the monastic order at Sekkau. From 1718 to 1741, 275 tons of copper were obtained from 3,850 tons of ore. In 1778, samples contained 6 per cent. of copper, 50 dwts. of silver and 18 dwts. of gold to the ton, but the average became so low that the mines were closed in 1789.

The veins are, as a rule, 5 feet thick, with a core of quartz and limestone. In some places copper and arsenical pyrites as large as a walnut

have been found, and also tennantite. Another mine, at some distance, was also formerly worked, but the ore now contains little copper, and the percentage of gold was always small. The mines cover an area of 12½ miles, but unfortunately the vein of ore is intermittent, and its course cannot be traced with precision. E.M.D.

PYRITES-MINING IN UPPER STYRIA.

Die Walchen bei Oeblarn: ein Kiesbergbau im Ennsthal. By DR. KARL A. REDLICH. *Berg- und Hüttenmännisches Jahrbuch der k. k. Bergakademien zu Leoben und Přibram und der königlich Ungarischen Bergakademie zu Schemnitz*, 1903, *vol. li., pages* 1-62, *and* 2 *plates.*

The ancient mining industry at Oeblarn has been recently resuscitated after a slumber of well nigh half a century, and the author gives in this memoir the results of investigations made among the newly opened-up ore-deposits, as well as the gist of the literature devoted to the district ever since Hans Adam Stampfer first described the mines in 1683. A complete bibliography (including manuscripts as well as printed works and maps), is followed by a detailed historical summary.

The rocks of the neighbourhood consist chiefly of garnet-mica-schists, among which are interbedded pure white crystalline limestones, folded into synclines and anticlines; and of quartz-phyllites (intermediate in age between the Archæan and the Silurian) in which occur the ore-deposits. The general strike is east-north-east and west-south-west, and the dip is 33 or 34 degrees to the north-north-east. There is plenty of evidence of disturbance and faulting.

Three main deposits, termed "veins," by the older authors, are recognizable. The highest, the Walchen ore-body, is really a partly-broken lenticle, 3½ feet thick at the outcrop, double that thickness at a depth of 200 feet, and thinning out to nothing towards the dip, at a depth of 650 feet. The Gottesgabe or God's Gift "reef," 590 feet lower down, separated at first from the Dreifaltigkeit or Trinity "reef" by 45 feet of barren ground, unites with this to form one deposit, varying in thickness from 4 inches to 3¾ feet, but occasionally attaining a maximum of 10 feet. On the whole, this deposit may be regarded as originally consisting of two lenticles, the uppermost of which has been worked out. Striking parallel with the main deposits are innumerable thin seamlets of pyrites, so thin indeed as to be unworkable. At the outcrop the ores are recognizable by their brown weathered gossans, really masses of ochre, which, in conjunction with the sericite-schists, serve as good indicators.

The Thaddeus adit, dating from the early years of the 18th century, over 3,400 feet in length, was reopened and somewhat lengthened in the autumn of 1897. About 40 waggon-loads are got from it monthly and are used up in a celluloid factory. Ordinary pyrites, indeed, forms the mass of the ore, in association with copper-pyrites. Occurrences of secondary importance are arsenical and magnetic pyrites, galena, blende, argentiferous fahlore, antimonite, etc. Small proportions of gold and silver are found in the iron- and copper-pyrites: several recent analyses of these are tabulated by the author.

With regard to the genesis of the deposits, he enunciates the following theory. Suppose a rock (unlike the surrounding country-rock) to have occupied their present position in the form of a bedded mass. Mountain-building movements take place, fissures are torn in the rocks and are infilled

with crush-material (?). Subsequent metamorphism occurs, obliterating nearly all traces of the fissures, and the whole appears to be one compact mass. Then fresh disturbances take place, fissures are once more opened up in it, and this time the presence of pyritous elements results in pyritic infilling. The substance which originally occupied the place now taken by the ore-deposits was probably limestone.

Statistics of the output of the mines, from 1570 to 1857, are followed by a detailed description of the old method of treatment of the ores. From this one gathers that the operation must, in later years at any rate, have been carried on at a loss. As a matter of fact, sulphur, under the new conditions, will be the chief product obtained from these mines; and then, if the annual output is much increased, a payable quantity of metal may be got from the roasted pyrites. L. L. B.

MINERALS OF THE TYROL.

Beitrag zur Geschichte der Baue des Berggerichtes an der Etsch, 1472-1659. *By* MAX REICHSRITTER VON WOLFSKRON. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1901, *vol. xlix., pages* 91-94.

In the Tyrolese valleys on the banks of the Adige extensive mining operations have been carried on for centuries for silver-bearing lead-ore, the existence of gold being little more than a tradition. Works were carried on throughout the sixteenth century at Nals, and in 1525 at Terlan; from the latter place the lead-ore was exported to Spain, while the ore dug at Nals was sent to Rattenberg. The works at Nals and Terlan employed at that time 163 men, but the mines were gradually worked out, as the ore became poor, and ceased to yield either silver or lead.

In Gsteyr, near Meran, a vein of lead-ore was discovered in 1548, and thirteen mines were opened, some being at a depth of only 4 or 5 feet, and therefore worked at small cost. Like the mines in Nals and Terlan, however, these mines gradually decayed, in spite of an effort made towards the end of the century to revive the industry. One cause for their failure was that the working of the mines interfered with the cultivation of the rich land in the Adige valley. The miners being mostly men foreign to the district, there was little desire to continue the work after the rich yield of the mines had begun to diminish, because the country-folk were able to earn a more comfortable living by agriculture. E. M. D.

THE LAURIUM MINES, GREECE.

Ueber den Bergbau im Laurion. By C. VON ERNST. *Berg- und Hüttenmännisches Jahrbuch der k. k. Bergakademien zu Leoben und Přibram und der königlich Ungarischen Bergakademie zu Schemnitz*, 1902, *vol. l., pages* 447-501, *with* 8 *figures in the text.*

The mining district of Laurium in Southern Attica covers an area of about 50,000 acres. The various centres are connected up with each other and with the harbours of Theriko and Ergastiria by tram-lines and narrow-gauge railways, and with Athens by a broad-gauge railway.

Speaking broadly, the rocks of the district consist of an alternation of marbles, dolomitic limestones and mica-schists, which overlie unconformably the Cretaceous limestones of Athens and Lykabettos. The whole series has

undergone folding and dislocation, with the result that the massif is traversed by numerous fissures, partly infilled with apophyses of the fine-grained granite or eurite of Plaka and partly with sulphidic ores. The rock-succession is as follows, in descending order:—(1) Upper ferruginous limestone, which forms the capping of many hills. (2) Upper micaceous slate or schist, partly weathered, containing white mica. (3) Middle limestone (marble): one variety is pink and schistose, and the other is bluish-grey and fine-grained. This forms the foot-wall, and No. 2 the hanging-wall, of an ore-body which consists chiefly of iron-ores, impregnated with galena, etc. (4) Lower micaceous slate or schist, forming the foot-wall (and No. 3 the hanging-wall) of a second ore-body, consisting in the northern area of manganiferous iron-ores, and in the southern of finely-granular argentiferous galena associated with chalybite, fluorspar and calcspar. (5) Lower marble, with impregnations of iron-pyrites and galena. (6) Micaceous slate or schist, between which and the underlying saccharoidal marble (of unknown thickness) lies the third ore-body, varying from 20 inches to 40 feet in thickness, and consisting of galena and cerussite. This deposit was largely worked by the ancients: in the foot-wall occurs a good deal of zinc-ore, in the form of nests, etc. Nearly all the above-described rocks are seamed by a network of fissure-veins infilled with calamine and galena. Besides the granite, already mentioned, various greenstone-dykes break through the massif. The ores are richest where schist forms the hanging-wall and limestone the foot-wall, and the proportion of zinc-ore tends to increase the deeper down one goes.

The explanation appears to be that the ore-bearing fluids, coming up from below reacted with greatest effect on the lowermost marble, leaching most of it away and depositing in its place zinc oxides. Thus impoverished, when they reached the higher limestone-beds the ore-bearing fluids proved less potent in inducing double chemical decomposition, etc. On the other hand, as the schists by their very texture would tend to check the upflow of the fluids, the limestone with a schistose roof would there be richest in ore.

The usually very compact lead-ore contains indeed only from 9 to 10 per cent. of metallic lead, but it is rich in silver, yielding 4½ pounds per ton of lead. The quality of the calamine varies: from the lowermost deposits 2,000 to 3,000 tons are got monthly, and have yielded as much as 65 per cent. of metallic zinc, but ores as rich as this are rarely obtained nowadays.

The author gives an elaborate and interesting description of the mining industry carried on in the Laurium district by the ancient Greeks. The slag-heaps left by them still contain from 7 to 14½ per cent. of metallic lead, but they appear to have been very successful in extracting most of the silver. The more recent history of the industry is fairly well known from other sources. It will be remembered that after a lapse of 2,000 years working was started on the slag-heaps in 1864. Since then enormous masses of slag have been found below water-level, where they were tipped over by the ancients into the sea, and the total amount of slag was still estimated in 1893 at 2½ millions of tons. The richest portion has now been almost all worked over. In addition to this there are the waste-heaps of the ancient mines, or *ekvolades*, and the remains of the ore-washings or *plinites*, from which a good deal of lead and silver has been got. The Greek metallurgical company founded in 1873 has not, however, confined itself to working over the old heapsteads, etc., but has opened up fresh mines, and in 1901, the output from these for the year amounted to 21,346 tons of manganiferous iron-ore, 12,679 tons of plumbiferous iron-ore, and 339 tons of zinc-ore.

The French Laurium company, founded in 1875, works some of the richest mines in the district, at Kameresa (where the Serpèri and Hilarion shafts have been sunk to a depth of 590 feet or so), Plaka, Suresa and Despilesa. The ores are sorted and smelted at Kypriano, where works on a magnificent scale have been laid out. The output for 1901 amounted to 10,730 tons of roasted calamine, 803 tons of plumbiferous calamine, 3,942 tons of ferruginous calamine, 454 tons of zinc-blende, 11,500 tons of red hæmatite, and 84,973 tons of manganiferous iron-ore. In addition to the two great companies, two or three other smaller companies are at work in the district, their mines being situated at Dardesa, Sunion, Daskalio, Seriphos, etc.

The total number of work-people employed in 1899 was 9,346, but the industry has since then fallen on evil days, and in the first half year of 1901 more than 2,000 workmen were perforce dismissed, as the prices of lead and zinc were so low that it did not pay to work any except the richest deposits. The constant inflow of water into the mines is one of the great difficulties with which the Laurium engineers have to battle.

L. L. B.

COAL-MINING IN DUTCH LIMBURG.

Steinkohlen in Niederländisch-Limburg. *By* HENRI ZONDERVAN. *Petermanns Mittheilungen*, 1901, *vol. xlvii.*, *pages* 187-190.

The Netherlands being mainly an accumulation of drift-deposits, and outcrops of older rocks occurring only in the east of the provinces of Gelderland and Overijssel and in the south of Limburg, mining enterprise in that country is restricted to a very small area. In fact, mining operations, in the true sense of the word, are in progress in Southern Limburg alone, and although at present conducted on a very modest scale they are destined to undergo considerable development in the near future. This hopeful view is based on the comparatively-recent discovery of a great extension of the coal-field, the seams in the new area being well worth working.

In part, the Limburg coal-field belongs to the Wurm basin (which is itself a small portion of the great belt of Coal-measures that stretch from Stadtberge in Westphalia to Valenciennes in French Flanders). But a number of new borings have revealed the presence in Limburg, north of the Wurm Coal-measures and separated from them by the saddleback ridge of Kerkrade, of another group of coal-bearing strata. This coal-field strikes south-west and north-east, and is cut by two main faults running south-east and north-west: the throw of one of these is 1,000 feet or so, and the maximum downthrow of the other is not yet known, as a bore-hole near Gangelt went down 1,640 feet without reaching the Coal-measures. The strata south-west of the last-named fault (known as the Sandwall or northern fault) can alone be regarded as workable, for north-east of it the thickness of the Tertiary deposits is so enormous, that shaft-sinking would prove too costly. East of Valkenburg, another bore-hole has struck the Coal-measures, but they are here unproductive; and, in view of this, the actual extension of the workable measures westward from the Sandwall fault may be reckoned at 6 or 7 miles. The probable boundaries of the new Limburg coal-field are then: east and north, the Sandwall; west, the barren strata of Valkenburg; and south, the Kerkrade ridge. Its area measures about 81 square miles: the overlying rocks are mainly Tertiary sandstones, Chalk and Greensand, none of which appear likely to enhance the difficulties

incident to mining operations. On the other hand, the frequent occurrence of heavily-watered sand-beds will complicate somewhat the labour of shaft-sinking, but will hardly prove a serious obstacle, unless the shafts have to be sunk to a very great depth.

The two Dutch localities where coal is now being mined are Kerkrade (for the Wurm basin) and Heerlen (for the Limburg basin). It is expected that more new pits will be started at the last-named place before long.

At Kerkrade, four seams are worked, down to a depth of 1,100 feet from the surface (or 600 feet below sea-level); the output in 1899 amounted to 122,796 tons, and in 1900 to 124,538 tons. The number of workpeople employed belowground was 291 and abovebank 80. Not far off from here is the Neu Prick colliery, which produced in 1899, from three seams, 46,040 tons of coal, the total number of workpeople employed being 145.

About 1870, boreholes were put down at thirty different places in what is now the new coal-field, and in nearly every case they struck coal. Mining concessions were obtained from the Dutch Government; but practically no use was made of them, partly in consequence of industrial depression, and partly because of the absence of means of transport. The last named desideratum, however, was attained by the building of the local railway-line which runs from Sittard to Heerlen and Herzogenrath. Thereafter, a serious beginning was made with mining work, and from 1893 onwards, company after company opened up collieries over a total area of 14,656 acres.

The seams west and south of the Feldbiss fault are chiefly "meagre" or "sand-coals"; at Heerlen, however, a "flaming" coal is found. North of the Feldbiss, both "flaming" and bituminous coals occur. The "meagre" coals in the government collieries and at Neu Prick-Bleyerheide, are anthracitic in character. They are tough and clean, burn slowly, almost without flame, and give off very little soot or dust. The only colliery at work at present near Heerlen is the Oranje-Nassau pit. Working four seams, it produced in 1899, 44,136 tons of coal, and employed 271 workpeople (192 belowground and 79 aboveground). It is estimated that when all the concessions recently taken up are being worked, the total production of the new Limburg field will amount to 10,000 tons *per diem*. If the whole of the available coal-area were worked, this figure could be trebled or quadrupled, and reckoning 290 working days in the year, the annual output could be increased to 11,500,000 tons. If this were so, the Netherlands, which imported in 1898 a little over 5,000,000 tons of coal, could in future be entirely self-supporting in that respect; the supply from their own collieries would be amply sufficient to cover all the requirements of the consumers, and not a single ton of coal need be got from abroad. On the contrary, Holland could enter the lists with other nations as a coal-exporter. The author confesses, however, that more than one decade is likely to elapse before this consummation is reached. Meanwhile, the Government have brought forward a Bill in the Netherlands Legislature, for the purpose of enacting that no further mining concessions shall be granted, but that the remaining area of the coal-field (two-thirds of the whole) shall be held and worked by the State. The committee of experts appointed by the Government to examine into the question had, however, previously reported in favour of conceding four-fifths of the coal-field to private enterprise and reserving only the remaining fifth (the choicest part, calculated to contain 800,000,000 tons of coal) for the State. This question is not yet settled.

L. L. B.

COAL-SEAMS AT TKVARTSHALI IN TRANS-CAUCASIA.

Die neu entdeckten Kohlenflötze von Tkwartschali im Kaukasus. By EM. LADOFF. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1901, *vol. xlix.*, *pages* 173-174.

Tkvartshali, in the province of Kutais, is about 34 miles from the coast, whence a good road leads to it. It is a wild and mountainous district traversed by numerous deep rivers, with vast primeval forests. Only the semi-civilized Abbasiers wander through it. These wild inhabitants have long known of the existence of coal, which they call "devils' blood," and hold in abhorrence. It was from their description that the first seam, 2½ feet thick, was discovered. It contains more ash than coal, but two other seams of good coal, 7 and 14 feet thick, were soon afterwards discovered. The coal-district covers an area of about 77 square miles, but has been little explored. The thill of the seams is sandstone, containing clay, and sometimes passing into shale, and the roof is conglomerate. In several places there are hot springs of sulphuretted hydrogen. There are many faults, the strata are much contorted, and in one place a vein of grey porphyrite occurs. A few fossils have been found. Variations in the thickness and colour of the seams are characteristic of the district. The coal-measures are cut through by rivers, which in their upper reaches run at a steep angle, and the coal often crops out at the surface.

The method of working the seams is primitive. In the deep river-ravines, the coal at the surface is simply dug out with pickaxe and shovel. Elsewhere, the strata are inclined at the same angle as the bed of the rivers, and lie far below them. Here, three holes, 300 feet apart, were bored by hand. One of them, sunk to a depth of 250 feet, cut through three seams of coal, 7, 11 and 18 feet thick respectively; and at a depth of 180 feet, a hot spring impregnated with sulphuretted hydrogen was tapped. The coal contained about 34 per cent. of ash. There are seven seams at Tkvartshali, one of which is 40 feet thick, but this is chiefly shale with thin beds of coal, and only three of the other seams are valuable. The ash usually exceeds 7 per cent. The coal can be coked and in this respect, Caucasian coal is remarkable, as even with 33 per cent. of ash it cakes into a solid mass. The coke is light, not brittle, and burns well in furnaces.

Unfortunately the development of the industry is hindered by the difficulty and expense of connecting the district with the sea. An ordinary railway would be too costly, but an electric or funicular railway might be constructed, if the natural features of the country were utilized. There are several waterfalls, from which power might be obtained. E. M. D.

COPPER-ORES OF SÜNIK, TRANSCAUCASIA.

Die Kupfererze der Sünikgruben im Gouvernement Elisabetpol, Transkaukasien. By — ERMISCH. *Zeitschrift für praktische Geologie*, 1902, *vol. x.*, *pages* 88-89.

Transcaucasia is extraordinarily rich in metalliferous ores, and among these copper seems to play an important part. The Sünik mines, district of Sangesur, in the government of Elisabetpol, are one of the three most considerable copper-mining enterprises in that part of the Russian Empire: they are near the frontiers of Persia and Asiatic Turkey, and their situation therefore is somewhat remote. The nearest railway-station, Evlach, is 125 miles distant, and it may be for this reason that, from the technical point of view, the Sünik mines have much leeway to make up. In the old days, the softer ore (bornite) used to be worked out by means of narrow, deep

and sloping shafts, while the somewhat harder ore (such as chalcopyrite) was left behind. Within the last five years, however, mining has been actively carried on, more in accordance with modern methods, and, recently, smelting-works have been built at Sünik, on the Manhes system.

The ore-bodies are undoubted vein-deposits, and the gangue is almost exclusively quartz. The chief ore is chalcopyrite, containing from 14 to 2[illegible] per cent. of metallic copper, seldom more. With it are associated, mixed together in one mass, iron-pyrites, bornite and antimony fahlore, and (very rarely) some native copper. At present no economic importance is attached to the gold-and-silver content of the copper-ores, which is said not to be inconsiderable. Precise data, however, are not forthcoming. So far, twenty veins are known, varying in thickness from 7 to 45 inches: taken altogether they form a channel striking north-westward through a massif of dark-green to blackish diabase. Fault-fissures in this diabase are numerous; they cut through the cupriferous veins, and are very unwelcome to the miner.

The workings are irregular narrow adits driven some 100 to 300 feet or so horizontally into the hillside: no true shaft, in the modern sense, has yet been sunk. In regard to water, all the conditions are very favourable for the mining industry. The use of dynamite has only just begun at Sünik, ordinary blasting-powder having been employed there till quite recently. Haulage is in a primitive stage indeed, for the miners bring to the surface, both the mine-water and the ores that they have won, in great leathern sacks. Yet the annual production has risen from 230 tons of metallic copper in 1890 to 806 tons in 1900. L. L. B.

THE PRESENT POSITION OF COPPER-MINING AND WORKS IN THE ZANGAZURSKY DISTRICT, ELISABETHPOL, TRANS-CAUCASIA.

The Present Position of Copper-mining and Works in the Zangazursky District, Elisabethpol, Trans-Caucasia. *By* N. SHOSTAK. 1901, 16 *pages.*

The copper-deposits of Zangazursky are situated near Evlach station on the Trans-Caspian railway. The absence of good communication with the railway has prevented these deposits from being opened up on a large scale.

The country-rock of the district is chiefly andesite. The ore is a copper-glance, together with lead-glance and zinc-blende in quartz-veins. The direction of the veins is north-west to south-east without any appreciable divergence or faulting. The veins do not narrow as they attain depth.

The development-work shows that the veins extend to a length of 7,000 feet with a width varying from 6 inches to 3½ feet, and the workings have extended to a depth of 700 feet. From 1858 to 1900, 9,643 tons of copper have been produced. In 1900, the output of copper was 800 tons. All the works are run with water-power, as coal costs £2 1s. per ton, wood, 10s. to 12s. per ton, and coke £7 per ton. The mine is robbed, only the rich parts of the veins being worked, without systematic development.

The cost of mining amounts to £2 10s. per ton of ore, and allowing for capital-expenditure the cost will be about £3 10s. per ton. The smelting of the ore, in old-fashioned furnaces, costs £3 12s. per ton, thus making a total cost of about £7 2s. per ton. In order to work at a profit under these conditions, 8 per cent. of copper is the minimum, and ore containing less than 7 per cent. is thrown on to the waste-heap. At the new works, erected at Sounthsky in 1897, the ore is now being smelted for £1 8s. per ton. The ore, in the first instance, is smelted to copper matte, and refined in converters to black copper and to pure copper in the *schpleizoffen*. R. W. D.

THE DONETZ COAL-FIELD, SOUTHERN RUSSIA.

Die Kohlen-industrie im Donetzbecken. By — TITTLER. *Zeitschrift für das Berg-, Hütten- und Salinen-wesen im Preussischen Staate*, 1901, *vol. xlix., Abhandlungen, pages* 477-480.

The Donetz basin is really a typical "plateau of erosion," the highest summits of which do not exceed an altitude of 1,130 feet. The elevations and depressions of the surface coincide here exactly with the geological structure of the Coal-measures. The Carboniferous deposits are of an unmistakably littoral type, and cover an area which extends over a length of 233 miles from east to west with a maximum breadth of 100 miles: they are in part overlain by saliferous red marls of Permian age, but they crop out at the surface over an extent of no less than 7,720 square miles.

The seams, as a rule rather thin, number more than 200: the workable coal mostly occurs in the Middle Group (horizon of *Spirifer mosquensis*) of the Upper Carboniferous system—as defined in that region. The seams usually dip between 15 and 20 degrees, high dips of 50 to 70 degrees being uncommon; in thickness they range from 2 to 5 feet, rarely attaining 6 feet. The coal varies in character from a good gas-coal to an excellent anthracite; the upper seams are generally of bituminous coal, and the lower of semi- or non-bituminous coal. One case is known of a seam which, on being followed along the strike, was found to contain all these varieties of coal passing one into the other. Sulphur is present in so large a proportion that the coal from the Ruchenko mine, containing from 1 to 1·3 per cent. of sulphur, is regarded as comparatively free from that undesirable ingredient. The percentage of ash varies from 5 to a maximum of 10. The coal-seams are interbedded with shales and sandstones, with occasional thin beds of *Fusulina*- and *Productus*-limestones.

It cannot be said that mining here is attended with any special difficulty. Pillar-work and overhand stoping are the methods usually employed. Some mines are very fiery, and all of these are provided with ventilators (30 ventilators on 17 mines, with a total capacity of 1,220,000 cubic feet per minute). Altogether at the present time there are 135 collieries at work in the field, with a combined annual output of about 7,500,000 tons. The depth of the shafts ranges from 100 to 1,250 feet. The 205 haulage-engines represent a total of 16,820 horsepower and the 212 pumping-engines can raise between them 3,530,000 cubic feet of water to the surface in 24 hours.

The high protective tariff alone enables the Donetz coal to compete with British coal in the harbours of the Sea of Azov and the Black Sea. On the other hand, the Donetz coal dominates completely the markets of Southern and Central Russia, right up to Moscow. The coke produced in the district by 2,860 ovens (mostly Coppé ovens), averaging about 1,000,000 tons *per annum*, is all consumed locally.

The number of workpeople employed in 1899 belowground was 40,000 and aboveground 10,000. Hewers earn from £3 5s. to £5 10s. a month, trammers from £2 12s. to £3 5s., surface-labourers the same, and the wages of the other workpeople are on a similar scale. This is in part due to the great number of religious festivals and saints' days which are kept as holidays, so that there are but 240 working-days in the year or 20 in the month, and the annual output per head is only 146 tons. L. L. B.

PLATINUM-MINING IN THE URAL.

Vorkommen und Gewinnung des Platins im Ural. By L. St. Rainer. *Berg- und Hüttenmännisches Jahrbuch der k. k. Bergakademien zu Leoben und Pŕibram und der königlich Ungarischen Bergakademie zu Schemnitz*, 1902, *vol. l., pages* 255-298, *with* 2 *figures in the text, and* 3 *plates.*

Premising that 95 per cent. of the world's output of platinum comes from the Ural, the author gives a brief history of platinum-mining in that region, supplemented by statistics of annual production from 1825 to 1900.

Scarcely a single gold-placer is worked along the whole chain of the Ural that does not contain some traces of the rarer metal platinum. The platinum-workings properly so-called are, however, practically confined to two districts:—that of Tagil and that of Goroblagodat, 74 miles farther north, their combined productive area being reckoned at 64 square miles or so. Economically the Goroblagodat field is by far the most important of the two; and the Tagil workings show signs of exhaustion, as they now yield only 17 per cent. of the total platinum-output of the Ural.

A brief sketch of the geology of the region leads to the pregnant conclusion that the occurrence of the platinum is genetically associated with that of the peridotite-rocks. Some Russian observers assert that the precious metal, in the Goroblagodat district, is also to be found in porphyrite-sills, in gabbro-diorites, syenite-gneisses and syenites; but the evidence for this is not yet regarded as altogether beyond doubt. Analyses of the crude ore are tabulated, showing that it always contains more or less iron and copper, besides osmium, iridium, ruthenium and palladium. The miners divide the ore into three grades: No. 1, containing 85 per cent. of pure platinum, from the Lower Iss and Tura river-valleys; No. 2, containing 82 per cent. of the metal, from the Upper Iss valley; and No. 3, containing 75 per cent. from Nizhni Tagilsk, where the ore is got out of the original matrix (chromite-bearing serpentine).

The so-called "eluvial" placers, consisting of weathered detritic material which has not been carried by water to any distance from its original *locus*, are generally poor in platinum, precisely because they have undergone so little natural concentration. The true alluvial deposits along the valleys are mantled by barren layers of varying thickness (from 10 to 130 feet or more), but the barren layers are seldom intercalated with platiniferous bands. In many places the bottom portion of the placer is indistinguishable from the highly-decomposed bed-rock. The rich paying alluvia consist of sand, loams and gravels, sometimes containing tusks and bones of mammoth, and vary in thickness from a minimum of 5 inches to a maximum of 10 feet.

The method of working the placers is described, and it is notable that in cases where an attempt has been made to economize time and labour by means of British machinery, the stupidity and want of discipline of the Tartar miners have in part nullified the advantages derivable from modern apparatus, with the result that slow manual labour has retained its primacy. The method of washing the alluvia is also described, and the author appears to think that a considerable amount of platinum is lost in the tailings, and that not a little is stolen by the miners (despite the vigilance of the authorities).

Within the past two years, dredging has been introduced in workings in the Iss valley, and the resulting economy in cost of output is estimated at 51 per cent. or even 57 per cent. The author points out, however, that the dredger often fails to scour away thoroughly the lowest (not seldom the

richest) layer of the placer immediately above the bed-rock; it fails too to scoop out the heavy metallic grains lying in the inequalities and hollows of the surface of the bed-rock itself. He remarks that no one yet seems to have thought of attaching a *caisson* to the dredger, capable of accommodating a certain number of workmen whose task it would be to scour completely the surface of the bed-rock.

In conclusion, the author draws attention to the fact that the richest platinum-deposits are practically exhausted, and that in many cases the miners are reduced to washing over and over again the old tailings. A marked diminution of output within the next 10 years is inevitable, unless new sources of supply be found, along some of the unexplored river-valleys on Count Shuvaloff's property and north of it (that is, beyond 61 degrees north latitude). It is curious to note that 44 per cent. of the platinum consumed in the United States is used up by the makers of artificial teeth, and equally remarkable statistics are cited from Austria-Hungary.

L. L. B.

LÅNGFALL ZINC-BLENDE MINE, SWEDEN.

Ueber die Gesteine der Zinkblendelagerstätte Långfallsgrube, bei Räfvåla in Schweden. By R. BECK. *Tschermak's Mineralogische und Petrographische Mittheilungen*, 1901, *vol. xx., pages* 382-389, *with 4 figures in the text.*

This mine is situated in the province of Dalecarlia, south of Lake Vessman, west of Ludvika, and belongs to the Saxberget Company. The first discovery of the ore-deposit was as recent as 1881 or 1882, and it appeared in the statistics of ore-production for the first time in 1891. The author has given a short description of the mine in his recently-published text-book,* but in the present paper he gives fuller particulars in regard to the country-rocks.

The ore occurs in the form of a bed 10 to 16 feet thick, underlying drift, and intercalated conformably with crystalline schists, which dip steeply southward. The predominant rock is a fine-grained flaky biotite-gneiss (of widespread occurrence in Central Sweden, and well known as the *locus* of many ore-deposits). It forms the floor of the ore-bed here, but passes into a coarsely slaty biotite-quartz rock, containing much sillimanite and extremely little felspar. The immediate roof of the ore-bed is formed by actinolite-rocks of varying mineralogical composition. Nevertheless, they are conspicuous for the occurrence of amphibole-anthophyllite, a type of actinolitic hornblende apparently new to Sweden. With the fibrous aggregates of this mineral, brown zinc-blende, copper-pyrites, and some galena are intimately intergrown. Microscopic examination shows the blende in extremely thin lamellæ thrust in between the cleavage-folia of the amphibole-anthophyllite, or matted together with it in an inextricable felt-like plexus.

The ore, then, is mainly zinc-blende; magnetic-pyrites, copper- and iron-pyrites, and argentiferous galena playing a comparatively subordinate part. Reasons are assigned for explaining the genesis of the deposit, as due to a secondary mineralization of a hornblendic rock originally rich in cordierite and spinel.

In many respects the Långfall ore-deposit is similar to the pyrites-deposits of Silberberg near Bodenmais (Bavaria), recently described by Dr. E. Wein-

* *Lehre von den Erzlagerstätten*, 1901, pages 476-477.

schenk.† With the latter's genetic hypothesis, however, the present author does not agree. He thinks that all the phenomena of corrosion and impregnation characteristic of both deposits are ultimately due to the intervention of thermal solutions. L. L. B.

IRON-MINES IN CENTRAL AND SOUTHERN SPAIN.

Datos geológico-mineros de varios Criaderos de Hierro de España. By L. MALLADA. *Boletin de la Comisión del Mapa geológico de España*, 1902, *series* 2, *vol. ci., pages* 153-203, *with* 5 *figures in the text.*

The author deals first of all with the mines in the Fuente del Arco and Guadalcanal districts, in the provinces of Badajoz and Seville. The Sierra de la Jayona forms the northern extremity of a ferruginous belt, some 38 miles in length from north-west to south-east, and varying in breadth from 600 to 5,000 feet. The deposits, miscalled "veins," are really long strings of "pockets," of irregular dimensions, the chief ore being a micaceous specular iron-ore, in places entirely pure, and containing 69 per cent. of the metal. Sometimes it is mixed with varying proportions of calcium, magnesium and iron carbonates. The genesis of these deposits is undoubtedly associated with the eruption of hornblendic porphyries, which invaded the surrounding Cambrian slates, carrying with them thermal waters or fumes charged with iron, which latter was ultimately precipitated in the cavities of the limestone, also of Cambrian age. In certain localities the ancients exploited the richer and more easily-workable portions of the deposits, but what they have left would well repay working nowadays. Great confidence is expressed in the still untouched mineral wealth of the Sierra de la Jayona, and the ores could be exported through Seville, by the suggested light railway (12½ miles long) which would join up with the line from Mérida to that city. On the other hand, the ores could be brought into the coal-field of Belmez for metallurgical purposes, by means of a still shorter light railway (5 miles) to the station of Fuente del Arco, which is joined by a line 43 miles long to Peñarroya, within the aforesaid coal-basin. The six mines of Guadalcanal proper are not working such rich deposits as those just described.

Proceeding southward, the author deals with the San Nicolas and Constantina districts in the province of Seville, and the Hornachuelos district in the province of Córdoba. The geological conditions are very similar to those described in the Sierra de Jayona. The same statement applies to the Feria deposits in the province of Badajoz, with the exception that here the intrusive igneous rocks are largely impregnated with ore. So too the extensive Luisa and Los Pedros mines in the Sierra de Cordóba, which forms the northern wall of the Guadalquivir valley, work ore-deposits varying in thickness from 40 inches to 6½ feet, the foot-wall being Cambrian slates, and the hanging-wall limestones, sometimes faulted or eroded away. The strings of pockets contain sometimes hæmatites and sometimes specular iron-ore.

In the Sierra del Madroño, near Hellín, province of Albacete, a vein of very pure hæmatite, averaging from 1 to rather more than 10 feet in thickness, is worked amid ashen-grey or white marls and limestones of Lower Cretaceous age. At the contact with the vein, the limestones are con-

† *Trans. Inst. M.E.*, 1901, vol. xxii., page 693.

verted into brecciated pinkish dolomites associated with carbonate of iron. The ore is not very siliceous, and analysis shows it to contain between 54 and 57 per cent. of metallic iron.

The author then turns to the Sierra Alhamilla in the province of Almeria. This mountain-range is mainly built of pale chlorite- and mica-schists of pre-Cambrian age, overlain uncomformably by yellowish and pinkish, more or less magnesian, limestones of Triassic age. The ore-deposits occur partly in pyritiferous quartz-veins which traverse the schists, and partly in a more bedded form, intercalated between these schists and the limestones. Here also the genesis of the ores is traced back to thermal waters, the upflow of which formed the moribund stage of the volcanic phenomena that took place in the district in late Tertiary (?) times. The hæmatites occur in irregular masses, varying according to the cavities eaten away in the dolomite by the lava-flows: sometimes they measure as much as 100 feet in thickness. The ore is strongly impregnated with manganese, containing from 3 to 5 per cent. of that metal. Phosphorus and sulphur are absent, and silica almost entirely so. The percentage of iron oscillates between 50 and 60, some samples frequently yielding even more. The ore is tough, and the fact that it does not tend to make much "small" or "dust" is considered an additional advantage.

The Sierra de Almagro, in the Cuevas de Vera district, in the same province, presents much the same geological conditions as those just described, but great masses of gypsum are interbedded with the limestones. And the constant association of the gypsum with the iron-ore deposits as well, leads to the inference that they are of contemporaneous origin. Wherever these minerals crop out, hard green diabases are found with them. The author gives a detailed description of the mines, the most important of which is that of Los Tres Pacos. The ore is an excellent dark-red hæmatite, never containing less than 60 per cent. of metallic iron. The distance to Villaricos harbour is only 8½ miles.

The mines of Atienza, in the province of Guadalajara, work masses of hæmatite interbedded with Silurian slates and sandstones. The author terminates with the description of a few deposits in the extreme north of Spain—those of Begonte in the province of Lugo (of no industrial importance) and those of Berástegui, in the province of Guipuzcoa. The latter occur in the form of bedded veins in the Cambrian slates. Here various ores of iron are associated with galena, blende, chalcopyrite, etc. L. L. B.

THE AURIFEROUS QUARTZ- AND OTHER ORE-DEPOSITS OF SIBERIA.

Les Gisements de Quartz aurifère en Sibérie. By A. BORDEAUX. *Annales des Mines*, 1902, *series* 10, *vol. ii., pages* 499-549, *and* 1 *plate.*

The author begins by stating that, on the one hand he does not propose to deal with the Altai district, and that, on the other he will not confine himself to the gold-bearing quartz-reefs, but will also describe the iron-, lead- and copper-ore deposits as opportunity arises.

The Achinsk district in Western Siberia forms part of the Obi river-basin, and here the crystalline schists are overlain by some 5,000 feet or more of Silurian, Devonian and Mesozoic sedimentaries with Tertiary and Glacial drifts. In the sedimentaries are numerous thermal springs containing iron,

manganese, magnesia and sulphur, and some beds are impregnated with cupriferous ores just as at Mansfeld. There are considerable iron-ore deposits at Abakansk, Irba and Kuznetzk. At the last-named locality coal of Permian age occurs, and Jurassic (?) coal-seams are of frequent occurrence elsewhere. The strata are nearly horizontal, the mountains take on tabular forms, and the scarps formed by the watercourses are often vertical.

From the station of Itate on the Trans-Siberian railway, a journey of 100 miles or so by road brings the traveller to Chebaki, which is a sort of central depôt whence all the mines of the district draw their supplies, stores, etc. The first mine described is that of Yoannovski or Podvintzeff, where gold was first discovered in September, 1899, and first worked about a twelvemonth later, yielding 35 to 36 parts of gold per million. The reef, some 15 or 20 feet thick, occurs as a dyke in diorite. At the foot of the mountain are rich placers (worked since 1853), containing gold in rounded nuggets. At the Tumani mine (where work had not yet begun in May, 1902), is another quartz-reef, with gold visible to the unaided eye, in diorite. Assays show it to yield 1 ounce per ton.

At the Bogom-Darovanny (or Ivanitzki) mine, gold was first found in 1896, but working was not begun till 1898. Its output has already attained considerable dimensions. The country-rock, here, is syenite: the quartz is milky, the gold very finely divided but very pure, and pyrites is of rare occurrence. The total cost of the mining plant: turbine, stamp-batteries, etc., is about £16,000. About 32 tons of veinstuff are worked through per day; wood-fuel exclusively is used. The prime cost is very irregular, but including taxes, wages, salaries, fuel, sinking-fund, etc., it amounts to exactly £2 per ton, and with a yield of 24 parts of gold per million, a very fair profit can be made. The yield, at the time of the author's visit in 1902, averaged 30 parts per million.

At present, the industrial development of the Achinsk district is bound up with its immense forests, but later on the Permian coal of Kuznetzk, yielding only 3 per cent. of ash, and said to be equal in quality to the best English coal, will come into play. The seams are numerous, and extend over a vast area. At Kuznetzk also, no less than 80,000,000 tons of excellent iron-ore have been proved.

In the north-eastern portion of the Minussinsk district are numerous auriferous placers, and there are some gold-quartz reefs. Hæmatite-deposits occur in the Suida valley, and yellow and red ochre in that of Karaskuir, while galena and other lead-ores are recorded from the Seiba, Pieshka and Izuirtak river-basins. The cupriferous veins observed in the porphyries of this region do not seem to be of industrial importance.

In the east, the important mining concession of the Irba basin includes splendid magnetite-deposits, yielding from 64½ to 67 per cent. of metallic iron, galena (not in sufficient quantity to repay working), and copper-ores (equally unsatisfactory from the industrial point of view).

In the south, copper-ores were worked and smelted for several years (1837-1847, and again after 1874), but the industry is now extinct. At Abakansk, the magnetite-mines, worked since 1869 or so, are increasing considerably their output. The ore yields from 61½ to 63½ per cent. of metallic iron.

Only 25 miles away from the town of Minussinsk, at Zhazikh, are coal-seams several feet thick. The coal yields the following results to analysis:—Carbon, 62·22 per cent.; combined water, 6·42; oxygen and nitrogen, 8·48;

hygroscopic water, 14·60; and ash, 8·28. The heating power is 7,239 calories. The auriferous quartz-reefs along the Chinese frontier near Abakansk are rich, but have not been developed, because of the general insecurity of the border-districts.

Splendid deposits of white marble occur over an immense area, and many other occurrences of lead and copper-ores (besides those already mentioned) were reported to the author in Western Siberia.

The remainder of the paper is devoted to a brief account of the mineral wealth of Eastern Siberia. The region of the Middle Vitim river, difficult of access, has aroused much attention of late years, because of the recent discovery there of rich placers and rich auriferous quartz-reefs. Copper-ore deposits also occur. As to the thin and not very promising quartz-veins of the Upper Vitim, the author declines to pronounce definitely an opinion.

Two syndicates are at work on the gold-quartz reefs of the Onone district, and the annual output of the precious metal at the Bielogolovy mine there (somewhat fluctuating) amounted in 1901 to 93 pounds (42 kilogrammes). Forewinning is not always pushed with sufficient rapidity to keep the stamp-batteries continuously at work, and this partly accounts for the disappointing results often obtained from Siberian gold-mines. The district of Nerchinsk is, or was, famous for its silver-mines, but it also contains gold-bearing veins. The mineral industry conducted there for well nigh two centuries with convict-labour (a very costly form of labour because of its bad quality), is now, however, practically extinct. In the Shilka district, the author found gold associated in a quartz-reef with pyrites and galena. Nearer the surface, the pyrites is oxidized to iron oxide. The reef, 6½ feet broad at the outcrop, widens to 26 feet at the bottom of a shaft some 50 feet deep. Assays give very promising results. Other quartz-reefs are known to occur, also antimony-ores, phosphorites, asphalt, and (it is whispered) petroleum.

On the island of Askold, 37 miles east of Vladivostok, the plant at a gold-mine crushes about 120 tons of quartz per month during the nine working months of the year (so long as the sea-coast is not icebound). About 130 workpeople (Koreans and Russians) are employed at this mine. Other quartz-veins have been proved on the neighbouring mainland, and in the Tuteka district are argentiferous lead-ore mines, the output of which goes mainly to England. The Tuteka ore yields 62 per cent. of metallic lead, and about 1 part per thousand of silver. In Nahodka Bay, which is government property, three thick seams of semi-anthracite have been proved, and at least 10,000,000 tons of coal are in sight, but the deposit is probably much more extensive. L. L. B.

THE MINERAL RESOURCES OF NORTHERN CHI-LI, CHINA.

Reise durch den nördlichen Theil der Provinz Chi-li. By KARL VOGELSANG. *Petermanns Mittheilungen*, 1901, *vol. xlvii., pages* 243-250 *and* 278-284, *and* 1 *plate.*

In September, 1899, the author made an excursion from Peking to the western hills, and visited the small coal-mines in the neighbourhood of the village of Wan-ya-tsen. These appear to be worked by the Chinese in a most primitive and unsystematic fashion. The seams are thin and much broken, the coal is of bad quality and is chiefly used for lime-burning. Nevertheless, from the slack, small spherical "briquettes" are made, and find a

ready sale in Peking. The selling price (quoted by the author) at the mine appears incredibly low: it works out at barely 1½d. per cwt. (?) The miner's daily wage, for 12 hours' work, is about 6d.

In the valley of Montakou, which opens out eastward, and narrows westward into a steep gorge, coal has been mined for untold ages, but in a very wasteful manner. Here also the seams are rather thin, but the quality of the coal is good: it is carried to Peking on camels, and sells there for about 28s. a ton, costing at the pit-mouth just half of what it costs in the capital.

The first auriferous occurrence described by the author consisted of narrow gold-quartz veins coursing through the hornblende-rock of the Sanyuen-pei-kou valley. Here, the Chinese had driven an adit about 100 feet long, and brought the quartz to-day in baskets. There were evidences of several unsuccessful diggings on the opposite (eastern) slope of the valley. Here, again the author was struck by the absence of method and wastefulness characteristic of Chinese mining. The gold-output in that neighbourhood is too insignificant to be of any industrial importance.

Wonderful stories were current concerning a new Eldorado, Che-lin on the banks of the Chao-ho, and wealthy Chinese had spent large sums on prospecting; but, so far as the author could ascertain, only one unimportant quartz-vein occurs thereabouts, in hornblende-rock. It is said that placers were successfully worked in the district in bygone years, but of these not a vestige is left. Nor does the immediate neighbourhood of Jehol (Cheng-te) boast any auriferous deposit worthy of mention. At Chun-ku-lo-kow, some distance north of the above-named town, workings had been begun, but were subsequently prohibited by the authorities and abandoned, on a quartz-reef which cropped out in places to a thickness of 10 feet. Some specimens assayed in Shang-hai yielded a very moderate amount of gold, 4 to 6 parts per million.

In the barren valley of Hung-hua-kow, in the neighbourhood of Chih-feng, are abandoned workings on a quartz-reef (in diorite-gabbro), specimens from which yielded to the author very unsatisfactory assays. Nevertheless, he is of opinion, from the general appearance of the country, that it would repay systematic prospecting.

North-east of Chih-feng, a town of 100,000 inhabitants, the author visited the coal-deposits of Yuen-pao-shan, in the Lao-ho valley. The coal is hard, and very like the brown coal of Bohemia. The seam, now being worked, varies in thickness from 5 to 10 feet, and underlies about 150 feet of gravel and sand. It is worked by means of long sloping galleries rather than shafts, in which steps are cut, one only being provided with a windlass. The coal is sold at about 14s. a ton, and is nearly all sent by pack-mules to Chih-feng. About 200 workpeople are employed: they are all housed in one huge shelter, and in addition to food, receive piece-wages (which work out at about 6d. per man per ton).

The author further describes his visits to the comparatively insignificant gold-mines of Chuan-shan-tse, and to the mines of Chin-chang-kow-hang (where both auriferous quartz-reef in hornblende-rock, and alluvial gold-deposits are worked). He concludes that, although gold-quartz reefs are of widespread occurrence in Northern Chi-li, they are mostly so narrow as to hardly repay working: new finds of importance are not to be expected, as the province has been pretty minutely prospected by the Chinese themselves, and he does not recommend the investment of foreign capital in that quarter.

L. L. B.

THE SHANSI COAL-FIELDS, CHINA.

The Coal-fields around Tsê Chou, Shansi, China. By NOAH FIELDS DRAKE. *Transactions of the American Institute of Mining Engineers*, 1900, *vol. xxx., pages* 261-277, *with* 8 *figures in the text.*

Tsê-chou is the principal city in that part of the Shansi coal-field here described. It lies some 300 miles south-west of Tientsin and 500 miles north-west by west of Shanghai. All the coal of the Tsê-chou region is anthracite; its average specific gravity is 1·5; and it is hard enough to support any weight that might be put on it in the blast-furnace. The percentage of sulphur is uniformly low, and that of ash—averaging 10 per cent.—is comparatively so for anthracite.

The rock-formations may be divided into three groups:—a lower group of limestone about 2,000 feet thick; a central group of shales, coal, sandstone, and a flint-bearing limestone aggregating about 300 feet thick; and an upper group of shales, clays and sandstones, exposing about 1,000 feet of strata. Over nearly all the valley and rolling lands there is a covering of lœss, which reaches in places 100 feet in thickness. With the exception of this covering, the rock-beds are apparently conformable throughout and, as a whole, lie comparatively level; but there is some conspicuous folding and faulting.

The workable coal lies in one bed about 250 feet above the flint-bearing limestone: there may, however, be a little coal below the limestone, since the principal coal-bed in Western Shansi lies underneath it. This workable coal-seam is probably not less than 22 to 23 feet thick, with a few thin shaly partings. If 22 feet be taken as the average thickness and 1·5 as the average specific gravity of the coal, there are about 3,000,000,000 tons of coal within the 150 square miles of coal-area in the Tsê-chou region, which is only a little of the ragged edge of the great coal-fields of Shansi.

There is a narrow strip in the northern part of the district, where iron-ore (hæmatite) is being mined by open pits from a stratum 2 to 3 feet thick. Fire-clays of good quality are abundant, and considerable quantities are now used by the Chinese for making cheap pottery. Sandstones occur in abundance, and, though too friable to be durable, are used by the Chinese for bridges, houses and road-paving. Massive limestones abound of good quality for building-stone, fluxing material, the manufacture of lime and probably of cement. Reddish-grey marble of fine structure, and black limestone suitable for monuments, are also found.

Practically all of the coal is mined through shafts varying from 50 to 300 feet in depth. The mining is done with pick and gad, no explosives being employed. The coal is hoisted in baskets containing about 300 pounds by windlasses, which are run by men, no steam being used. The coal is mined by driving tunnels through the coal-bed from the bottom of the shaft, and at intervals along the tunnel-ways large quantities of coal are removed, leaving more or less circular rooms, from 40 to 50 feet in diameter.

The output of the district is probably not less than 50,000 tons per annum. For local use, the coal is carried away in little carts drawn by oxen; but the greater part is taken down the mountains by pack-animals, along rough and steep trails paved with stone and 12 to 14 feet wide.

The Pekin Syndicate, a joint English-Italian company, has concessions from the Chinese government to work the coal of the Tsê-chou region as well as most of the Shansi coal-fields. Some proposed railways leading from the Tsê-chou region to outlets on the plains and to shipping ports are described and indicated on a map. A. W. G.

THE MINERAL RESOURCES OF SOUTH-WESTERN CHINA AND TONGKING.

Étude géologique et minière des Provinces Chinoises voisines du Tonkin. By A. LECLÈRE. *Annales des Mines*, 1901, *series* 9, *vol. xx.*, *pages* 287-402 *and* 405-492, *and* 12 *plates*.

This exhaustive memoir gives a very full account of the observations made by the author, in the course of a journey which he undertook on behalf of the French Ministry of the Colonies, through those districts which are to be opened up by the prolongation of the (French) Indo-Chinese railways. He started on December 5th, 1897, and returned on July 15th, 1899, bringing back with him more than a ton of rock- and mineral-specimens and fossils. With the exception of the Tongking delta, the whole of the region traversed is extremely rugged and mountainous, attaining altitudes of 10,000 feet or so near the Blue river. The rock-succession, described in ascending order, is:—(1) Crystalline schists; (2) pre-Cambrian or Sinian quartzites, etc., presenting features very similar to those of Britanny and the Ardennes; (3) Devonian limestones and shales; (4) Lower Carboniferous shales, grits, and limestones with coal-seams, with which are associated contemporaneous eruptive rocks (sills, dykes, etc.); (5) Upper Carboniferous limestones, the basal beds being "fetid limestone"; (6) Lower Permian limestones and shales; (7) Middle Permian limestones, etc., with coal-seams; (8) Upper Permian clays, sandstones and conglomerates, in part saliferous and gypsiferous; (9) Lower and Middle Triassic limestones and shales; (10) Upper Triassic variegated marls, overlain by Rhætic shales and grits, with coal-seams; (11) Liassic cavernous dolomite and grits, the latter sometimes containing angular bits of coal; (12) Tertiary deposits, characterized in Tongking by a string of small coal-basins, forming mostly inliers in the gneiss along the Red river. (The best-known of these basins is that of Yen Bay.) These Tertiary deposits exhibit all the features of torrential sedimentation; (13) Quaternary lacustrine formations, calcareous tufas, and peat-beds often with seams of lignite. The Silurian, Oolitic and Cretaceous systems appear to be entirely wanting in the region here described.

About 100 pages are occupied with a record of the facts noted by the author along fifteen different lines of route. His first itinerary was along the coast from Haiphong north-eastward to Kebao. Here in the Konga district, about 260,000 tons of coal are being wrought annually, the greater part of the opencast working. The coal-bearing formation (of Rhætic age) dips very slightly south-eastward, and the seams near the outcrop are sufficiently rich to have precluded for the present any endeavour to carry the workings very deep down. In the island of Kebao, the seams striking north-north-eastward assume an increasingly steep dip until they pitch almost vertically, and often pinch out altogether deeper down. The Lanessan shaft has been sunk to a depth of 1,000 feet, but further exploration-work has been temporarily suspended. What coal has been got shows a high percentage of ash, whereas the Hongay coal is very pure, though friable and "meagre." To make patent fuel out of it, Japanese coal has to be added, as well as a large proportion of pitch. Other Rhætic coal-deposits are worked on a small scale in the north of Haiphong.

A large number of mining-concessions have been obtained for working copper-, antimony-, lead- and silver-ores, the district of Monkay being especially rich in these. Moreover, cobaltiferous manganese is said to occur in the lagoon east of Kwangyen, and nickel north-east of Hongay.

The second itinerary was along the Red river, from Haiphong to Laokay. Navigation is increasingly obstructed by moving sandbanks, the origin of which the author traces to the comparatively recent, extravagant deforestation of Yunnan. Small Tertiary coal-basins occur at several localities along the river, and exploration work has been carried on at the Haidzuong pit (drowned at the time of the author's visit), at a depth of about 130 feet below the surface. The coal yields on analysis 35 per cent. of volatile matter and a considerable quantity of ash. A graphite-deposit has been discovered in the Lower Carboniferous rocks 6¼ miles east of Yenbay, and traces of petroleum are observed on the right bank of the river, 2½ miles west of that town. Mining concessions have been granted for certain important coal-outcrops in the Lower Carboniferous near Pho-lu.

The third itinerary consisted in a series of prospecting traverses around Laokay. At Langhang, 2½ miles up stream, seamlets of lustrous coal occur in a torrential deposit of sands, clays and conglomerates. This coal yields 35 per cent. of volatile matter and 4 per cent. of ferruginous ash. Outcrops of Lower Carboniferous coal are also described. Near Baxhot, Banmac, etc., and other localities, both on the French and on the Chinese bank of the river, excellent magnetite-deposits occur in association with milky quartz among strata of Devonian age. Mention is made of the old copper-mine of Mot-dong, 5 miles south-east of Longpo, worked 50 years ago by the Annamites, but no opinion is expressed by the author as to the present value of the deposit.

The fourth itinerary was devoted to a series of similar traverses around Mongtse. Near Manhao are considerable outcrops of a rather earthy coal, in yellowish grit of Tertiary age. This miserable village marks the uttermost limit of navigation at low water (that is, in the dry season); junks of not more than 3 tons' burthen may sail that far up the river. A sometimes very shaly coal occurs in the *Productus*-limestone (Permian?) of Sin-chiem, Pa-che-kay, etc. It is largely used in the lime-kilns of the district, but the coal needs first to be moulded into briquettes and dried, and these are "coked" in large heaps. There is a residue of 7 per cent. of ash.

The author visited the tin-mines of Tomuko, but circumstances (in the shape of a raid by 250 marauding miners on his small caravan) prevented him from seeing the much more important stanniferous deposits of Tsementong. These miners, assembled in bands, periodically pillage the surrounding country, the desolate aspect of which is enhanced by the complete absence of trees (all destroyed for wood-fuel and charcoal) and the great scarcity of water. Some of the tinstone occurs in veins in the Triassic limestones, but there are also what may be termed "secondary ore-bodies," masses resulting from the decomposition of the limestones and the veins. These masses can be generally worked opencast. The tinstone, after washing, calcining, etc., yields 75 per cent. of raw tin.

After providing himself with a larger escort of soldiery, the author proceeded to Kotin, the great centre of the tin-mining industry in that region. At Malaken, the red clay-veins worked for tinstone are proving more and more barren in that ore, while the proportion of copper in the infilling increases. The stuff thrown on the waste-heaps by the Chinese miners is really a rich copper-oxide ore. In the Permo-Triassic grits of Veitaochan, 7½ miles south of Mientien, is a copper-mine employing a score of workpeople. The ore, after being hand-picked, is sent by pack-horses to Yunnan-sen. It contains from 30 to 40 per cent. of metallic copper, but the percentage of silica is sometimes as high as 40.

The fifth and sixth itineraries consisted in a journey from Mongtse to Yunnan-sen, and in excursions around the last-named city. About 40 miles from Mongtse, at Puchao-pa, a coal-outcrop, up to 65 feet thick, is worked opencast. It is overlain by variegated grits, which are themselves capped by remnants of infra-Liassic limestone. The mineral yielded the following analysis:—Hygroscopic water, 6 per cent.; volatile matter, 38 per cent.; fixed carbon, 51 per cent.; and ash, 5 per cent. The calorific power is estimated as equivalent to 7,060 calories. At present, the annual output hardly exceeds 3,000 tons.

The coal-workings of Niuké are only 22 miles distant from Mongtse. They are opened up in a seam about 4 feet thick, dipping eastward below the limestones. Sloping galleries have been driven downward for a length of about 1,000 feet. The mineral contains from 30 to 35 per cent. of volatile substances, while the ash does not average more than 6 per cent. East and north of Mi Leu, a seam about 4 feet thick is worked by comparatively shallow pits (35 to 50 feet deep) in the Rhætic shales. An average sample yielded the following analysis:—Ash, 9·54 per cent.; volatile matter, 36·8 per cent.; and coke, 63·2 per cent. The calorific power is 7,081 calories. The coal is conveyed in wains, holding not less than ½ ton, drawn by oxen, down to the city of Mi-leu.

Near Tutsa, three or four coal-seams, varying in thickness from 5 to 6½ feet, occur in a group of grits and shales, among which are intercalated sills of eruptive rock (porphyrite), and underlain by a great mass of the same porphyrite. The seams are actively worked by means of several well-timbered drifts. A very lustrous coal is got, having the following composition:—Hygroscopic water, 1·3 per cent.; volatile matter, 15 per cent.; fixed carbon, 73·7 per cent.; and ash, 10 per cent. The calorific power is 7,500 calories. The coal is so friable, that it is found necessary to convert it immediately into coke at the very pit-mouth. The coke sells at about 14 shillings per ton (500 *sapeks* per horse-load). Some hundred miners are employed at a daily wage ranging from 2½d. to 5d., and the annual output does not exceed 2,500 tons.

A very similar coal is got at Yunnan-sen, where it has been largely used for lime-burning, and from the neighbourhood of Ilyang.

In the Mitsao and Imen district are important copper-ore and iron-ore deposits, and brine-springs. The author describes and figures the primitive plant with which the iron-foundries there are provided.

The seventh itinerary was from Yunnan-sen to Tungchuan. In the province of Yunnan, cupriferous deposits are numerous, but the bad condition of the wheel-tracks and the growing scarcity of timber combine to reduce the number of possible workings, as only those deposits can now be mined which are close to smelting-furnaces, and only those smelting-furnaces can be kept up which are close to a forest. The mandarins have so worked the law that the landowners have no interest in the preservation of the forests and these are being laid waste beyond hope of recovery. At present, Tungchuan and Wisi are the principal centres of the copper-industry in Yunnan moreover a good deal of coal is worked in the Carboniferous strata around Tungchuan. At the Lupu mine, the copper-ores occur actually in a great mass of porphyrite, in a sort of horizontal or bedded vein: the infilling consists of barium sulphate, with which are associated copper oxide and native copper. The Tangtan mines are, however, of still greater importance: the ores (in the Laochang working) occur in a sort of stockwork.

and were originally pyritous, but are almost entirely decomposed into carbonate, and these are mixed with the Laosinchang copper-pyrites, the whole being calcined in furnaces fed with wood-fuel. The annual output from Tangtan averages 500 tons of raw copper: this undergoes further treatment at Tungchuan. Deposits of argentiferous galena and manganiferous cobalt-ore are mentioned as occurring in the neighbourhood of Lupu.

The eighth itinerary was westward from Tungchuan to the mouth of the Kinho, a tributary of the Kinshakiang or Blue river. Round the city of Wei-li, much coal is worked in the Coal-measures. The brass-foundries and such like industries are especially active. The auriferous sands of the Kinho are extensively washed by the Chinese, in a patriarchal fashion: they afford a bare living to the easily contented natives, but appear to be of no industrial importance.

The ninth itinerary was south-westward, from the Gold river or Kinho mouth, to Tali on the headwaters of the Mekong. The author records repeatedly outcrops of Rhætic coal on this traverse. The mineral is of excellent quality, and is worked in various localities by the Chinese. The average of five analyses shows the following percentage composition:—Volatile matter, 31·5; fixed carbon, 54·7; hygroscopic water, 5; and ash, 5·35. The calorific power is 7,965 calories. The land-sale price (in the neighbourhood of Mashang) is stated to average barely 4s. per ton. Tali is the great market for the produce of the copper, lead and zinc-veins of the Likiang and Wisi district. Moreover, rock-salt and gypsum are worked in the Upper Permian formation north of that city.

The author went back south-eastward from Tali to Yunnan-sen (tenth itinerary), passing on the way the great salt-mines of He-tsin. At Chao-chiu, there is a big trade in orpiment, brought from Monghoa, some 25 miles south. About 200 tons of this ore (finest quality) are marketed there annually. The "salt-mines" of He-tsin and Langtsin should perhaps be properly called "brine-shafts." The brine is pumped up by hand-pumps from the Triassic strata, some of the shafts going down as much as 300 feet from the surface, and delivered into batteries of evaporating-pans. The industry constitutes an Imperial monopoly, but is leased out to syndicates which receive a fixed price for the salt according to quality; they are bound to deliver the whole output to the Imperial authorities, who resell the salt to the consumer at a high profit (150 per cent. or so), while the actual miners are assumed to make a profit of about 10 per cent.

The eleventh and twelfth itineraries were from Yunnan-sen to Kweiyang-sen by Hing-gni. At Lanmuchang rather poor coal is worked in the Middle Permian strata. It was formerly used for the distillation of mercury, obtained from cinnabar-veins in the grey *Productus*-limestone. Cinnabar-deposits are numerous in this region, but they remain unworked, as the Chinese are hostile to any re-invasion of the province by Musulman miners. Other outcrops of Permian coal are described, but these are of less importance than the Rhætic coal worked around Ngan-shuen. The mineral is very lustrous, hard, generally "meagre," and does not make good coke. It contains little water, but yields as much as 20 per cent. of ash. Good Rhætic coal crops out in many localities north-west of Kweiyangsen, and its land-sale price varies from 8s. 4d. to 10s. per ton. Moreover, outcrops of bituminous coking coal are described in the shales underlying the Permo-Carboniferous limestones of Wei-ning, etc.

Fron Kweiyangsen the author proceeded to Kweilin-sen, the capital city of Kwang-si. He saw workings of Rhætic coal and Permo-Triassic

gypsum on this thirteenth itinerary. He returned then southward by Nan-ning to Hanoi.

The third part of the memoir deals largely with the future prospects of mining industry in the region described. With regard to Palæozoic coal (Carboniferous to Middle Permian), the most favourable field of operations is the neighbourhood of Yunnan-sen. As we have seen, however, it is the Rhætic coal-measures which in this portion of the Chinese Empire assume an importance and an extension far beyond anything [of similar age?] in Europe. The mineral is generally of good quality, and the amount available is estimated at something like 20,000,000,000 tons. From the French point of view (facility of communications with Tongking) the best area for starting operations would be the western border of the Mongtse massif.

The iron-ore deposits, especially those near Yunnan-sen and Trinh-thuong in Tongking, may possibly give rise to an active metallurgical industry in combination with the coal-mines. Of the stanniferous deposits, the author speaks less hopefully, but the reserves of copper-ore in Yunnan are considerable and would probably repay European methods of working.

A translation in full is given of the mining regulations drawn up by the Chinese Government in fulfilment of the agreement of June 12th, 1897, whereby it was stipulated that French engineers and industrialists should work the mines in the three provinces of Kwangtong, Kwangsi and Yunnan.

The general tone of the memoir indicates clearly that those three provinces are regarded by the French government officials as an exclusively French "sphere of influence," a belief which such journeys as that of the author help, more or less, to translate into fact. L. L. B.

STANNIFEROUS DEPOSITS OF HIN-BUN, TONGKING.

Sur les Gisements stannifères de Hin-Boun (Laos). By A. LACROIX. *Bulletin de la Société française de Minéralogie*, 1901, *vol. xxiv., pages* 422-425.

A French company is engaged in exploration-work on certain tin-ore deposits in the province of Kammun (Laos). These have long been worked, in a very primitive fashion indeed, by the natives. The mine is called Hin-bun, because it is situated in a small tributary valley of that river, which is itself a left-bank tributary of the Me-kong. The ore is dug out of a hillside in a limestone-district where there are no eruptive rocks. It does not appear to be in place, but it is so little water-worn that it cannot have travelled far, and there is every expectation of finding shortly the original ore-body. The poor ore consists of limonite, varying in structure from cavernous to compact or concretionary, in which are disseminated prismatic quartz-crystals. The rich ore is a very compact crystalline yellow mass, made up of cassiterite-needles and quartz-prisms, impregnated with limonite. The cassiterite in many instances resembles very closely in appearance the "needle tin-ore" of Cornwall. None of the usual associates of cassiterite (topaz, mica, apatite, wolfram, etc.), occur in the Hin-Bun deposit. The limonite is possibly a pseudomorph after pyrites, although no absolute evidence of this is forthcoming. On the whole the author concludes that the cassiterite here occurs as a primary mineral in the ferruginous gossan of a sulphide-deposit, analogous to that of Campiglia in Tuscany. Comparison may also be made with the sulphidic antimony-bearing veins of Potosi (Bolivia), as analysis shows that the Hin-bun ore contains about 4 per cent. of antimony and a little lead. L. L. B.

THE PULACAYO SILVER-MINES, BOLIVIA.

Mina Pulacayo. *By* CÁRLOS G. AVALOS. *Boletin de la Sociedad Nacional de Mineria*, 1901, *series* 3, *vol. xiii., pages* 171-184, *with* 1 *figure in the text.*

The output of these mines in 1899 amounted to about 230 tons of silver, say between 4 and 5 per cent. of the total output from all countries in the world. The Pulacayo deposit occurs in one of the mountain-ranges which branch off from the main cordillera of the Andes; the mountains are made up of trachytic rocks which bear testimony to the volcanic eruptions that at one time burst through the conglomerates, sands and clays of Tertiary age forming the southern portion of the Bolivian high plateau. It is with these trachytes that the great argentiferous vein is intimately associated: where the volcanic rocks give place to sedimentaries, so too does the ore disappear. The workings extend over a length of 7,700 feet and a depth of 2,500 feet (reckoning from the highest point of the outcrop to the lowest or sump-level). The great vein strikes east and west, pitches northward, possesses a maximum thickness of 13 feet and tends to narrow as it goes deeper down. The principal ores found in it are tetrahedrite (containing up to 10 per cent. of silver), galena (with 2 per cent.), blende, copper-pyrites and iron-pyrites (the three last-named contain still smaller percentages of silver than the galena). Towards the surface all these metallic sulphides give place to their respective oxides and sulphates. A frequent non-metallic associate is barium sulphate, which diminishes in quantity concurrently with the increase of depth from the surface, and finally disappears altogether at the lower levels. Galena is most abundant at the intermediate levels; lower down its place is taken by blende and pyrites, and, at a point very nearly reached by the present workings, the vein is entirely made up of the two last-named sulphides and therewith ceases to be of industrial importance. Not much water was met with at first; but, of late years, as the workings were pushed deeper down, thermal springs of which there was no trace at the surface, were tapped, and they flooded the lower levels in continually increasing volume; in fact, the lowest levels remain flooded to the present day. A curious circumstance is that the superficial, pluvial waters which percolate downward, decomposing on their way the sulphides left in the old workings and becoming thereby strongly acid, are neutralized by the thermal waters; and thus the water pumped from the mine does not corrode the pumping-plant. The thermal springs met with at the lower levels indicate temperatures of 108° and 136° Fahr.; they hold in solution considerable quantities of carbon dioxide and small proportions of sulphuretted hydrogen. Fatal accidents have occurred in the mine, due to the evolution of the carbonic-acid gas from these waters: in one case, more than 20 lives were lost. Only one mine, the Pique Central, possesses pumping machinery of any importance, consisting of a Bullock compound engine (American) of 300 horsepower, and a Cornish duplex pump. Steam is provided by seven Lancashire boilers (Galloway) capable of developing 200 horsepower each, and from them the San Leon, Rothschild and Ramérez mines derive their motive power, as well as the Pique Central. The author shows in detail that the present plant is inadequate to meet the demands made upon it. British coal appears to be the sole fuel used.

The remedy for the difficulties hinted at appears to be the construction of a tunnel some 28,000 feet in length, which would reach the sump-level of the workings, and would be available both for drainage and ventilation.

L. L. B.

THE PARRY SOUND DISTRICT, EASTERN ONTARIO, CANADA.

Mining Developments in Eastern Ontario. *By* KIRBY THOMAS. *The Engineering and Mining Journal* [*New York*], 1902, *vol. lxxiv., pages* 186-87.

The Parry Sound district is located on the eastern centre of Georgian Bay and along Parry Sound. The city of Parry Sound is reached by deep-water navigation from the Great Lakes by Georgian Bay, and it is the terminus of the Canada-Atlantic railroad.

The rocks of the Parry Sound district are of the older geological series, although their exact horizon is not yet fully determined. The prevailing rocks are gneisses and schists. A peculiar and prevailing rock about Parry Sound is a garnetiferous schist. The rocks are all very much disturbed and contorted, and, at Parry Sound particularly, show extreme flexions. There are numerous small quartz-veins and several large pegmatitic dykes. In some cases these dykes may be traced for miles, and the prevailing crystals of felspar and mica, with some uncrystallized quartz and hornblende, are massive. In the Valentyne location, about 12 miles north of Parry Sound, one of these pegmatitic veins is mined for mica and felspar. The country is very rough and much glaciated. Probably 50 per cent. of the surface is glistening with uncovered rock.

The principal mineral channel appears to lie parallel to Parry Sound and extends for many miles either way. In general, it is from 1,000 to 1,400 feet wide, and the mineral veins or beds occur as extended and more or less parallel lenses, having the general direction of the mineral channel (north-east and south-west), and generally dipping at a high angle or almost vertical. At several points, the beds aggregate from 300 to 400 feet wide. They are from a few feet to 30 or 40 feet thick, and are generally indicated on the surface by an iron-stained capping. The ore appears to be in the zones or fractures along what is probably the line of an uprise and there is every geological indication of going to depth.

The ore varies at different points, but generally contains iron-pyrites and chalcopyrite. At some points, the copper occurs as chalcocite and bornite. In some locations, zinc occurs in the form of spalerite, sometimes running as high as 15 per cent. Some gold is found with nearly all the ores, the values running from 12s. 6d. to £2 (3 to 10 dollars) per ton. In the Lafex mine, an assay of 2½ per cent. nickel was shown. The copper-values vary: -The Wilcot, at a depth of 80 feet, gave a value of 9½ per cent. across a 30 feet vein. At the McGowan location, masses of bornite weighing several tons, running as high as 54 per cent. in copper, were taken out at or near the surface in open-cuts. Seven car-loads of this ore shipped to New Jersey gave an average value of 16 per cent. in copper. It is claimed that the McGowan ore has been thrown up from below, and is an indication of what will be found at depth in other parts of the zone.

The Parry Sound district promises to become primarily a producer of copper, and incidentally a producer of nickel, zinc and gold.

X. Y. Z.

ASBESTOS IN CANADA.

Vorkommen und Gewinnung von Asbest in Canada. *By* FRITZ CIRKEL. *Zeitschrift für praktische Geologie*, 1903, *vol. xi., pages* 123-131, *with* 3 *figures in the text.*

In 1901, the output of asbestos throughout the world amounted to 41,8[illegible] tons, 38,560 of which were obtained from Canada. About 1870, asbestos

deposits were discovered in the serpentine-hills of Thetford, district of Coleraine, in the east of the province of Quebec, but it was not until many years later that the discovery was turned to practical account. From 1879 onwards, the development of the asbestos-mining industry in the dominion has been extraordinarily rapid, and 12 companies are now at work, with a total capital verging on £1,000,000.

The author devotes his attention mainly to the serpentine- or chrysotile-variety of asbestos (hydrated silicate of magnesia) as being of far greater industrial importance than the brittle amphibole- or hornblende-asbestos (a silicate of lime and magnesia). The colour varies from olive-green to whitish, and there is one rare occurrence known to the author in the Ottawa district, which presents an extraordinarily fine fibrous texture with a dark-blue colour. He points out that a fine elastic quality of asbestos always contains more water than a poorer brittle variety. Add to this the fact that, if an asbestos-fibre be subjected for some time to a very high temperature, it becomes brittle. Evidently, then, there is an intimate relationship between the quantity of combined water in the mineral and its fibrous structure.

The Templeton variety was worked about 1890 in the crystalline limestones of the Ottawa district, but its occurrence was found to be of so restricted a nature that the workings were given up after two years. Nevertheless the author considers the Templeton asbestos of such extreme geological interest that he gives a lengthy description of the occurrence.

He then proceeds to describe the (commercially) far more important Thetford and Black Lake deposits, situated close to the railway between Sherbrook and Quebec, about 150 miles west of Montreal. He gives a map showing the distribution of the serpentines in the province of Quebec: these occur in three distinct areas. The easternmost, that of the Gaspé Peninsula, yields small veins of asbestos in the serpentine, but not in sufficient number to repay working. Of the Mount Albert area too, the same statement holds good, but with the reservation that, owing to its inaccessibility, that region has not been sufficiently investigated. In the Thetford and Black Lake district, the serpentine forms entire ranges of hills from 650 to 1,000 feet high. This part alone of the central area yields asbestos in sufficient quantity to repay working.

The third or south-western district stretches from Danville into the State of Vermont. The serpentine occurs often in the form of isolated hills, but hardly anywhere has asbestos been found in large quantities so far. However, that area may repay more thorough prospecting.

The Thetford type of asbestos occurs in serpentine associated with black, grey or green schists, also subsidiary quartzitic conglomerates and sandstones, all of Cambrian age. The association of diorite with these is noticeable, and in places the actual passage of diorite into the serpentine can be seen. Granulite, which is often found between the diorite and the serpentine, is generally regarded in the district as a good indicator of asbestos. This mineral occurs in irregular narrow veins (4 to 5 inches thick at most) in the serpentine, is very elastic and silky, and of a dark colour. Black Lake, only 4 miles from Thetford, produces a somewhat more vitreous and brittle asbestos, the mineral having been probably deprived of part of its combined water by the intrusion into the neighbouring rock of masses of eruptive granulite.

The author mentions, but does not decide as to, the relative merits of

the two theories in vogue concerning the genesis of the asbestos-deposits. The lateral-secretion theory assumes that fissures were formed in the serpentine-magma as the result of cooling and contraction, which fissures were later slowly infilled with magnesia-bearing solutions. The other theory does not postulate the existence of fissures, but derives the asbestos from the alteration of olivine and serpentine at a very high temperature. The workings are mainly opencast, and the better mineral is (or was until lately) graded or sorted and picked by hand, as it was found that machine-"picking" damaged the fine fibre. Details are given as to the cost of production and relative amount of output of the different qualities, from "first crude" down to "asbestic." L. L. B.

THE AURIFEROUS PLACERS OF CHILE.

Los Lavaderos auríferos de Chile. By A. ORREGO CORTES. *Boletin de la Sociedad Nacional de Mineria*, 1903, *series* 3, *vol. xv.*, *pages* 49-64.

In the Chilian placers, the gold occurs as a rule in the form of dust or very small grains. Occasional finds of fairly large nuggets are, however, recorded, such as those seen by the author at the Nahuelbuta diggings in 1895, which varied in weight from 6 to 22 ounces troy. According to the analyses tabulated by him, Chilian native gold always contains, in addition to varying percentages of silver, small amounts of copper and iron. He estimates the value of the gold obtained from Chilian territory, from the time of the Spanish *conquistadores* down to our own day, at about £100,000,000.

The coastal cordillera, which ranges from north to south along the Pacific seaboard, is chiefly made up of granitic rocks, which here and there throw off transverse spurs penetrating some 15 or 20 leagues inland. The formation is seamed by innumerable gold-bearing and copper-bearing quartz-veins of extremely variable thickness (from several feet down to fractions of an inch). The gold in many of the placers is evidently derived from these rocks, the result of weathering by various agencies and decomposition. In the fine sands, the precious metal is distributed throughout the deposit from top to bottom, but in the so-called *cascajos* or coarse gravels the gold is concentrated near the floor of the placer. Some of the coast-district placers lying at the foot of the granite-ridges, are covered, and have indeed been preserved by, a deposit many feet thick, of a clay which is a decomposition-residue of the granite. Accordingly, in order to work the placers, shafts have to be driven through this clay to various depths, until the rich *circa* or bed-rock is reached, as at Loica, Melipilla, etc.

Entering upon the detailed description of the placers, the author deals first of all with the fine sands of Carelmapu, on the extreme southern coast of Chile. Certain assays carried out by him showed the proportion of gold here to vary from 0·09 to 0·70 per million, but down on the sea-beach, where the wash of the waves has effected a sort of natural concentration, much richer sands occur, containing from 10 to 35 parts per million. These auriferous sands have been proved to a depth exceeding 26 feet. There are similar placers at Cucao, and at Chacao Channel in the island of Chiloé.

In the placers of Quilacoya, 8 leagues north-east of Concepcion, the sands are coarser, and consist of quartz-grains (in part crystalline), mica, and the other constituents of granite. The native gold occurs in the form of flakes, and was evidently derived from quartz-veins in the neighbourhood.

The coarse auriferous gravels of Marga Marga rest upon granitic rocks and those of Catapilco on syenites. An American syndicate was organized several years ago to work the last-named placers by hydraulicking, and expended nearly the whole of its capital in cutting canals and other preparatory works, only to find that the water-supply was inadequate. Nothing further appears to have been done in the matter since then.

After referring to the placers of Loica, Yalé, Andacollo (the coarse gravels of which have been profitably worked for centuries), Casuto, etc., the author points out that placer-deposits all over Chile are still awaiting development by modern methods. Those concerned appear to be hesitating as to the best method of working them. For the instruction of his countrymen, the author proceeds to give a short description of the principal methods in use in the United States and New Zealand, such as hydraulicking, dredging, etc. L. L. B.

THE COPPER-MINES OF TAMAYA, CHILE.

El Mineral de Tamaya. By ISAAC VARAS C. *Actes de la Société Scientifique du Chili*, 1901, *vol. xi., pages* 30-41.

This mining field, which in its day ranked among the first of those where cupriferous veins were worked, is at present in a state of decadence, chiefly for two reasons:—(1) Many of the best veins have been worked out, and (2) the levels in several of the mines have been invaded by water and submerged. On the other hand, it is yet possible that in the still unexplored portions of the field, new metalliferous veins may be discovered which will serve to keep the industry alive for a longer period than can at present be foreseen. Its forlorn condition is, in the author's opinion, mainly due to the drowning of the workings. This began with the rains of 1888; and then, the exceptionally wet winter of 1891 caused floods in the mines, the effects of which it was the less possible to stave off that there was a concurrent scarcity of labour due to the unsettled condition of politics. From that time, a sort of paralysis seems to have overtaken Tamaya, but the recent rise in the price of copper, though it has hardly made itself felt in its full force there as yet, will undoubtedly prove beneficial—from the miners' point of view. A few fresh workings have been opened on the secondary veins, and renewed activity has been lately evident in old mines that were formerly of considerable importance. Among these may be mentioned the Llano Blanco and the Patos mines.

The author describes briefly the mines working the principal vein. The deepest is the Rosario mine, which goes down to 1,935 feet vertical below the outcrop. At this depth, the vein still yields good ore, containing 28 per cent. of metallic copper. The Lecaros gallery, the greatest work of its kind in South America, after a course of upwards of 1¼ miles, debouches into this mine at the depth of 920 feet; and, forming a natural drainage-level, it has in part preserved the several mines with which it communicates from being flooded out. The Guias mine, not reaching a depth of more than 623 feet below the outcrop, comprises an immense extent of unexplored ground, and there is reason to believe that it will prove of great importance in the future. Innumerable mines have been opened up on the secondary veins: among these, the Patos mine, already mentioned, has yielded good masses of ore, containing from 28 to 30 per cent. of metallic copper.

The revival of the mining industry of Tamaya depends, in the author's

opinion, firstly, on a systematic exploration of the still untouched areas; secondly, on a combined drainage of the mines by means of an electric plant, and by lengthening the Urmeneta gallery so as to communicate with and drain the mines of the northern portion of the field; and thirdly, on the unification of the mines, as far as possible, under one management. The railway-freights are very high, and the remedy would seem to be the purchase by the Chilian Government of the line which runs to Tongoi.

L. L. B.

THE MINING-FIELD OF CARACOLES, CHILE.

Caracoles: Revista Minera. By FELIPE LABASTIE. *Boletin de la Sociedad Nacional de Mineria*, 1903, *series* 3, *vol. xv.*, *pages* 113-125, *and* 1 *plate*.

For the past fifteen years the four silver-producing provinces of Northern Chile have suffered much from the long-continued crisis which has befallen the world's trade in that metal, and the annual output is now barely 10 per cent. of what it was in the years between 1840 and 1894. But what affects the district of Caracoles more especially nowadays is the want of enterprising capitalists, and the need for more extensive exploration-work. In former times, mining was carried on there in an unmethodical, wasteful, reckless fashion, but the author appears to think that capital and knowledge prudently and methodically applied will assuredly bring about a revival of the mineral industry on a grand scale. Attention is directed to the three principal mines still at work in the district.

The Valencianita mine works the great reef known as the Corrida de Senda, which has been proved over a length of 2 miles; parallel to this (3,300 feet to the west) runs the reef known as the Gran Corrida de Caracoles, which, with its bifurcations extends over a length of 5¼ miles. Both are extremely rich. There are innumerable veins and veinlets transverse to these, varying in thickness from 2 inches to 6½ feet. The ore is got in the Valencianita mine between the depths of 385 and 590 feet; the Recuerdo mine did not strike really payable ore till a depth of 846 feet had been reached, and the author makes a point of the fact that much ore in Caracoles remains to be worked at fairly considerable depths. The Sud America mine also works the Gran Corrida de Caracoles.

A brief description is given of the geology, from which it may be gathered that the Jurassic rocks are overlain, as well as intruded into and much crushed, disturbed and otherwise altered by later eruptive porphyries and trachytes. Especially is it at the contact with the porphyries that the metalliferous veins are observed. To the eruptive phenomena also does the author attribute the rugged contours of the district.

Stress is laid on the splendid results attained in the Recuerdo mine, though inflows of water at first, and then difficulties of ventilation, had to be overcome. The infilling of the vein is very complex—there are both carbonated and sulphuretted ores of lead, silver and iron, as well as native silver.

Although not explicitly stated to be so, this paper appears to constitute the first of a series on the Caracoles district. L. L. B.

THE MINERAL RESOURCES OF ECUADOR.

Les Gîtes minéraux de l'Équateur. By C. VAN ISSCHOT. *Annales des Mines*, 1901, *series* 9, *vol. xx., pages* 97-102.

At present, in the statistics of production of precious metals, Ecuador occupies a lower place than her neighbours, Peru on the south and Colombia on the north, and yet in the old days of the Spanish domination the territory of Ecuador was one of the chief areas of gold-production on the American continent. The output of silver on the other hand was never considerable, and by no means corresponded to the natural resources which Ecuador possesses in the shape of argentiferous veins. Mining enterprise, checked by the war of independence against Spain, remained in abeyance until 1876 when the Ecuadorian government initiated some prospecting work, especially in the Zaruma district. Thereupon several companies were formed to work the gold-quartz reefs, but what with insufficient capital, and what with bad management, they all came to grief within a short time.

At present, only two mining companies are at work in the Republic of Ecuador. One works the auriferous quartz-reefs which cut through the porphyries of the Zaruma district, some 50 miles distant from the Gulf of Guayaquil. The "reefs" average 40 inches in thickness, and contain gold in the free state down to depths of 80 and 100 feet: below this the gold is generally found in combination with sulphides. In the Mina Grande, where the "reef" attains a maximum thickness of 20 feet, the average yield of gold is 20 parts per million, of which only one third can be extracted by amalgamation. So far it has not been found possible to treat the remainder with economically satisfactory results, even by the cyanide process. The district, which covers an area of about 40 square miles, is traversed by numerous streams and torrents capable of furnishing abundant motive power. Timber, for structural purposes, is very costly on account of the difficulties of transport, and there is no fuel naturally available on the spot. The free gold is really an alloy, of 734 parts of gold with 266 parts of silver per 1,000.

In the province of Esmeraldas, huge auriferous placers are being worked by a company on the hydraulicking system along the banks of the Rio Santiago. The average yield is estimated at 4d. or 5d. per cubic yard. The author has prospected other placers near Angostura, Uimbi, Cachavi and Bogota, and estimates that a similar output could be obtained from them, but these are at present being worked by the blacks, who are content to extract just enough gold to supply their very primitive wants. All these gold-bearing alluvia contain platinum.

No serious work is being done on silver-mines at present. Some ores were exported to Germany in 1893-1894, and one lot of 77 tons sold at Freiberg yielded 1 per cent. of silver, and a small proportion of gold. The mine whence these were got is now abandoned, for want of capital. Water-power (in abundance) and timber (both for structural purposes and for fuel) are available on the spot. The ore, chiefly iron-pyrites and copper-pyrites, with argentiferous grey copper-ore, could be very economically treated by lixiviation. Abandoned silver-mines are also to be found in the neighbourhood of Canar.

Argentiferous and auriferous pyrites, mixed with galena, occurs in a thick vein, off the Cuenca road, some 34 miles from Guayaquil. The ore yields on assay 15 to 22 per cent. of copper, 10 to 40 per cent. of lead, and as much as 0·6 per cent. of silver. Moreover argentiferous galena, containing

up to 0·25 per cent. of silver, has been found at several other localities, especially at Malacatos near Loja.

Mercury does occur in the metallic state in various alluvial deposits, but nowhere in such quantity as to repay working.

Petroleum is found along the Pacific seaboard, in strata belonging to the same geological formation as those whence the oil is obtained farther south, in Peru. It impregnates sandy beds close to the surface, and the inhabitants dig shallow wells, 10 to 12 feet deep, where the oil, dripping out from the sand, collects, together with brine. The author thinks that if adequate search were made, by means of deep borings, industrially important natural reservoirs of oil would be struck.

Anthracite is recorded from Riobamba, and exploration work is proceeding on a lignite-deposit near Loja. The coal-outcrops of Azogues, Malacatos and Penipo, even if they prove workable, are so far in the interior of the country that the difficulties connected with transport are likely to constitute an insuperable obstacle to successful enterprise.

The mining legislation of Ecuador is conceived in a very liberal spirit. An annual tax of £4 on mines in full work is payable to the State, and in cases of suspension of work the tax is reduced to 17s. The necessary plant, tools, explosives, chemical reagents, etc., can be imported into the country free of duty. In fact, the sole obstacles to mining enterprise are the absence of roads and the want of capital. L. L. B.

THE PETROLEUM-INDUSTRY OF PERU.

La Industria del Petróleo en el Perú en 1901. *By* ALEJANDRO GARLAND. *Boletin del Cuerpo de Ingenieros de Minas del Perú*, 1902, *No.* 2, 14 *pages and* 4 *plates.*

At the end of 1901, no less than 269 concessions for working petroleum had been taken out, most of them being situated in the districts of Tumbes and Payta. In the former district, a French syndicate and an Italian firm appear to be the chief concessionaries, while in the latter district a British company and an American syndicate take the front rank. About a fifth of the total number of concessions, in the hands of various individuals and companies, remain so far unworked.

The total sales of Peruvian crude oil in the year 1901 amounted to 6,400,000 gallons, those of kerosene to 516,920 gallons, benzine 667,412 gallons, and residues 1,983,500 gallons. Of this output by far the greater portion is credited to the London Pacific Petroleum Company of Talara, and nearly the whole of the remainder to the Piaggio establishment at Zorritos.

The French syndicate, after a lapse of two years, resumed boring operations, putting down 5 bore-holes, in some cases to a depth of 1,800 feet, without striking oil (except an insignificant quantity at about 500 feet belowground). The American syndicate, whose property lies about 7 miles farther north of Talara, at Amarillos, had so far put down only one boring, to a depth of 1,200 feet, and this without striking oil.

In round numbers, the oil-field employs at present about 500 persons and the concessions cover an area of 3,700 acres or so.

No very definite opinion can be hazarded at present (according to the author) as regards the future of the industry. The result of the borings carried out so far is to show that the nearer the sea-shore they are put

down, the greater are the probabilities of striking oil. Natural reservoirs of any importance have only been found on the coast, at Zorritos, Punta Pariñas and Punta Agujas. It looks as if the great bulk of the petroleum-deposits lay out to sea, beneath the waters of the Pacific, and as if a portion of the Peruvian coast-line merely marked the eastern fringe of the field. Evidence is cited in confirmation of this hypothesis, and attention is drawn to the fact that the newly-discovered petroleum-deposits near Los Angeles in California are largely worked beneath the sea.* Their output is more than twelve times as great as the Peruvian. L. L. B.

THE CROWN MOUNTAIN GOLD-MINE AND MILL, GEORGIA.

The Crown Mountain Gold-mine and Mill, Georgia. By HENRY V. MAXWELL. *The Engineering and Mining Journal* [*New York*], 1901, *vol. lxxii., pages* 355-356, *with* 4 *illustrations in the text.*

The Crown Mountain mine, Dahlonega, Georgia, possesses the first thoroughly equipped, combined mining, milling and sluicing gold-plant in the south, and is the first to utilize water-power in generating, and transmitting electrically, power for gold-mining purposes.

Hydraulic mining being the basis of this enterprise, water-rights were secured at a point 12 miles from Dahlonega, where, by making 2 miles of canal, the union of three streams was effected without dams, and the head-waters of the Chestatee river dropped 97 feet upon a wheel of 800 horsepower capacity. Directly connected on the water-wheel shaft is a two-phase generator of 500 kilowatts. The wheel and dynamo run at 514 revolutions per minute, and deliver 568 ampères per phase. The current is generated at 440 volts, transformed to three-phase at 12,000 volts, then transmitted 12 miles to the mill, and 13 miles to a pumping station on the Chestatee river, at the foot of Crown Mountain, where, at both points it is again transformed to two-phase, at 400 volts, and used at that pressure on all the motors.

At the pumping station, a Dean triplex pump, operated electrically and geared to its motor in the ratio of 20 to 1, easily lifts 1,500 gallons of water per minute through a 12 inches pipe to a reservoir on Crown Mountain about 550 feet above the river. From the reservoir, the water is distributed to four monitors or giants, three operating under a pressure of some 200 feet near the base of the mountain, while the fourth is working upon the saprolite-bodies of the summit; this giant is acting under direct pressure from a force-pump driven by compressed air. The air-compressor also furnishes air for hoisting, drilling, etc., at two working shafts as well as for operating the force-pump. From the points of operation of the giants over 5,000 feet of flumes, supplied with riffles throughout their length, have been constructed, and through these flumes the entire product of the mine is sluiced to the mill.

The heavy ore is broken with hammers into sizes admitting of transportation through the flumes, and an arrangement of grizzlies within the flumes separates the finer from the coarser sizes. The ores are dealt with in the usual way, the heavier ore first passing through a Dodge crusher, and thence into the feed-bins. Here are placed 50 stamps of 950 pounds

* *Trans. Inst. M.E.*, 1901, vol. xxii., page 729.

in 10 batteries of 5 each. Through these the ore passes on to 10 Wilfley tables. The finer ore passing through the grizzlies is treated on two Huntingdon mills, below which are also Wilfley tables. In both mills electro-plated copper-plates are used for the amalgamation of the free gold.

X. Y. Z.

GOLD-MINING IN THE SOUTHERN APPALACHIANS.

Gold-mining in the Southern Appalachians. *By* JOSEPH HYDE PRATT. *The Engineering and Mining Journal* [*New York*], 1902, *vol. lxxiv., pages* 241-242.

The area embracing the gold-fields of the Southern Appalachians extends from near Baltimore in a south-westerly direction across Maryland, Virginia, North and South Carolina, Georgia and Alabama. The writer gives a synopsis of the mining being done in the south, with the exception of Georgia, which is not considered in the paper, either statistically or otherwise.

Gold-mining in the region has been prosecuted for over a century, but systematic mining has not been undertaken until within the last decade of the nineteenth century. With the exhaustion of the placer-deposits, attention was turned to the veins from which they had been derived. As a rule these veins contain low-grade ores in quantity, and it is the method of treatment rather than the amount of ore that requires consideration. Many of the ore-bodies consist of beds in the schists and slates impregnated with auriferous pyrites and of imperfectly conformable lenticular veins and stringers of quartz. Where the upper portion of these have been thoroughly altered and decomposed, they were formerly worked for their free-gold contents, but as sulphides were encountered they were abandoned. These large deposits of low-grade ores are capable of being mined in enormous quantities, and offer a promising field for a cheap process of recovering the values. While the chlorination process has been worked successfully, it is highly probable that the cyanide process can be adapted to these ores.

During the past ten years, the production (apart from Georgia) has averaged about £40,000 (200,000 dollars) per annum, the larger proportion of which has come from one or two mines, showing clearly that when these low-grade ores are worked on a large scale they they can be treated profitably.

Many natural conditions favour mining in this region: forests for lumber, mine-timber and cord-wood are near at hand; cheap labour is abundant and skilled labour is also cheaper than in the western mining camps; climatic conditions permit nearly continuous mining all the year round, and at many of the mining localities there is abundance of water-power available for the installation of electric-power plants. X. Y. Z.

COAL-MINING IN KANSAS.

Kansas Coal-mining. *By* W. R. CRANE. *The Engineering and Mining Journal* [*New York*], 1901, *vol. lxxii., pages* 748-752, *with* 7 *illustrations in the text.*

The coal-area of Kansas comprises about 20,000 square miles, within the western Central area of Carboniferous strata. About three-fourths of this field is productive, the western portion being barren. Mining is most extensive

in the south-eastern part of the State, principally in Cherokee and Crawford counties. Taken as a whole, the coal is uniform in quality, and the bulk of it is bituminous coal. At Cherokee, Cherokee county, the coal was found by test to have the highest calorific value of any in the State, 15 pounds of water being evaporated for every pound of coal burned *(sic)*. At Osage City, the calorific power drops to about 10 pounds, and continues to decrease towards the higher geological horizons on the north and west.

The Kansas coals occur in shale-beds, alternating with limestone-strata of varying thickness and an occasional unconformable sandstone-bar, usually lenticular in form, which partially or entirely cuts out the coal. These beds of sandstone are more abundant in the southern part of the State. The Weir-Pittsburg lower seam averages about 40 and the upper about 30 inches in thickness. The lower stratum dips westward at about 16 or 20 feet to the mile, while the lower stratum dips with an inclination of from 6 to 8 feet per mile less, indicating that during the interval between the deposition of the two beds, there was an excessive westerly thickening of the shale-deposits. No serious faulting exists, although it is true that faults with displacements varying from a few inches to 8 feet have been met with.

A peculiar feature, especially in Cherokee and Crawford counties, is the common occurrence of what are known as "horse-backs" or "clay-veins." The source of these disturbances was probably the Ozark uplift, the centre of which upheaval is located a hundred miles or so to the eastward. The Kansas coal-beds, lying as they do at the outer limit of the disturbed area, were only slightly affected, and as a rule, only fissures were formed. Afterward, the pressure of the superincumbent strata, acting on the clay-beds beneath the coal, forced the clays upward into the fissured strata, thus forming the clay-veins known as "horse-backs."

Besides horse-backs, there are other formations known as "pots," "kettles" or "bells," which seem to be exaggerated forms of unconformable strata commonly known as "rolls" and "slips." The origin of the horse-backs and bells is quite different; the horse-backs are younger than the coal-seams that they intersect, while the bells and the coal-strata were formed contemporaneously. As for the rest, the bells were probably the result of cessations in the deposition of the formative materials produced by external conditions, such as exist to-day in swamps and sluggish streams, where eddy-currents and sudden inrushes of sediment and organic matter are of common occurrence.

The existence of these numerous horse-backs and bells exerts its effect both on methods of prospecting and actual working. Test-holes must be drilled at any point where a shaft is to be sunk. Serious loss has resulted from the ignoring of this rule. In one case, a shaft was sunk ¼ mile distant from a test-hole in all confidence that the same conditions would be found, but the completion of the shaft discovered the fact that the coal had been cut out or rendered useless by the great number of horse-backs that crossed and re-crossed each other.

The most prevalent system of working is room-and-pillar. There are two reasons for this:—(1) The mines are comparatively shallow and the surface-lands valuable; and (2) the coal being so much cut up by horse-backs, these can without difficulty be utilized as supports for the roof. The room-and-pillar system is most practised in the counties of Cherokee, Crawford and Bourbon, in which counties the horse-backs are most abundant. In the mines farther north and north-west, the seams are thinner, the horse-

backs are less numerous, and more longwall working is found. But by far the greater part of the coal is mined by room-and-pillar, though nearly as many mines are worked by one system as the other. Coal-mining machines have been used quite extensively in some mines, and are still employed in longwall work, although not so much as formerly. X. Y. Z.

THE QUICKSILVER-MINES OF BREWSTER COUNTY, TEXAS.

The Quicksilver-mines of Brewster County, Texas. *By* E. P. SPALDING. *The Engineering and Mining Journal* [*New York*], 1901, *vol. lxxi., pages* 749-750, *with* 8 *illustrations in the text.*

In the south-western part of Brewster county, Texas, present indications point to one of the most important and productive deposits of cinnabar in the United States. The locality is within what is known as the "Big Bend County," and lies about 10 miles north-east of the entrance to the Grand Cañon of the Rio Grande.

The country-rock is a Cretaceous limestone upheaved by igneous protrusions and cut by igneous dykes and faulting planes. Much evidence exists of the action of powerful currents of water. Stream-beds and dry washes have cut several hundred feet through the hard limestone, and the denudation has been enormous. A section of the strata obtained in the Grand Cañon is 1,700 feet thick. The main belt, in which the cinnabar occurs in payable quantities, is confined to certain well-defined limits, constituting a zone 6 miles long and 2 miles wide. Prospecting has proved the existence of large quantities of surface-ore ranging from ½ to 5 per cent. of quicksilver, and considerable quantities have been found ranging up to 18 per cent. Very high-grade ore occurs in bunches and pockets, assaying from 40 to 78 per cent., and these pockets have been found with sufficient frequency to raise materially the average tenour of the large quantity of low-grade surface-material now being furnaced.

The cinnabar found here, as a rule, is of the crystalline variety, having the characteristic colour of pure cinnabar. Quicksilver is also found in the native state filling cavities in the limestone, and as globules in crevices of rocks impregnated with cinnabar. As a rule, the cinnabar is found impregnating a clay-like rock or marl, and the softer portions of the limestone and breccia along faulting lines and in calcite-veins and stringers. But the writer has noted it in every class of rock found in the district, even as a coating on an eruptive basaltic rock. This points to a very general distribution of the metal throughout the zone.

The rich pockets occur as replacements of the country-rock, and in places there is evidence that the mineral-bearing solutions have come up through fissures and deposited their metallic contents at points where conditions favoured concentration and deposition. This would point to a surface rather than to a deep-seated deposit, and while there are reasons for supposing that workable values will be found at considerable depth, much remains to be proved seeing that, as yet, the deepest working is only 65 feet from the surface. During the visit of the writer, several nuggets of nearly pure cinnabar, worn smooth and round, were found in a ravine. Investigation resulted in the discovery of a pocket from which about 20 tons of ore was taken, assaying from 40 to 75 per cent., or between £2,000 and £3,000 (12,000 to 15,000 dollars) in value. X. Y. Z.

II.—BAROMETER, THERMOMETER, ETC., READINGS FOR THE YEAR 1902.

By M. WALTON BROWN.

The barometer, thermometer, etc., readings have been supplied by permission of the authorities of Glasgow and Kew Observatories, and give some idea of the variations of atmospheric temperature and pressure in the intervening districts in which mining operations are chiefly carried on in this country.

The barometer at Kew is 34 feet, and at Glasgow is 180 feet, above sea-level. The barometer readings at Glasgow have been reduced to 32 feet above sea-level, by the addition of 0·150 inch to each reading, and the barometrical readings at both observatories are reduced to 32° Fahr.

The statistics of fatal explosions in collieries are obtained from the annual reports of H.M. Inspectors of Mines, and are also printed upon the diagrams (Plates XXVI. and XXVII.) recording the meteorological observations.

The times recorded are Greenwich mean time, in which midnight equals 0 or 24 hours.

TABLE I.—SUMMARY OF EXPLOSIONS OF FIRE-DAMP OR COAL-DUST IN THE SEVERAL MINES-INSPECTION DISTRICTS DURING 1902.

Mines-inspection Districts.	Fatal Accidents.			Non-fatal Accidents.	
	No.	Deaths.	Injured.	No.	Injured.
Cardiff	2	9	1	5	6
Durham	1	1	1	3	5
Ireland	0	0	0	0	0
Liverpool	4	14	9	2	6
Manchester	0	0	0	0	0
Midland	0	0	0	12*	11
Newcastle-upon-Tyne ...	2	4	0	8	13
Scotland, East	4	9	1	18	22
Do. West	3	4	1	45	57
Southern	1	16	18	0	0
Staffordshire	2	2	1	11	14
Swansea	2	2	0	24	32
Yorkshire	2	2	1	5	6
Totals	23	63	33	133*	172

* Including an explosion by which no persons were injured.

TABLE II.—LIST OF FATAL EXPLOSIONS OF FIRE-DAMP OR COAL-DUST IN COLLIERIES IN THE SEVERAL MINES-INSPECTION DISTRICTS DURING 1902.

1902.	Colliery.	Mines-inspection Districts.	Deaths	No. of Persons Injured.
Mar. 3, 18·20	Pemberton	Liverpool	2	0
April 2, 20·15	Garswood Hall (No. 9 Sinking Pit)	Do. ...	9	2
„ 3, 9·30	Glencraig	Scotland, East ...	4	0
„ 19, 8·30	Benarty	Do. ...	1	1
May 14, 6·0	Todmorden Moor ...	Yorkshire	1	0
„ 21, 7·30	Dinnington	Newcastle-upon-Tyne	1	0
June 4, 3·0	Fochriw	Cardiff	8	0
July 4, 20·15	Woodhorn	Newcastle-upon-Tyne	3	0
„ 8, 13·30	Elba	Swansea	1	0
„ 9, 8·30	Wrexham and Acton ...	Liverpool	1	6
„ 19, 7·45	Collena	Cardiff	1	1
„ 26, 6·40	Shut End (No. 13 Pit) ...	Staffordshire ...	1	0
„ 26, 7·0	Cleland	Scotland, East ...	1	0
„ 29, 20·30	Darran	Swansea	1	0
Aug. 1, 7·30	Pumpherston (Oil-shale)	Scotland, East ...	3	0
„ 15, 14·40	Skellyton (No. 3 Pit) ...	Scotland, West ...	2	0
„ 23, 2·30	Park Mill	Yorkshire	1	1
Sept. 3, 23·30	McLaren	Southern	16	18
Oct. 3, 9·30	Blair (No. 2 Pit) ...	Scotland, West ...	1	1
„ 15, 8·30	Holmside (Oswald Pit) ...	Durham	1	1
Nov. 25, 7·0	Prior's Lee (Stafford No. 2 Pit)	Staffordshire ...	1	1
Dec. 1, 15·30	East Plean (No. 3 Pit) ...	Scotland, West ...	1	0
„ 9, 7·0	Orrell	Liverpool	2	1
			63	33

TABLE III.—LIST OF NON-FATAL EXPLOSIONS OF FIRE-DAMP OR COAL-DUST IN COLLIERIES IN THE SEVERAL MINES-INSPECTION DISTRICTS DURING 1902.

1902.	Colliery.	Mines-inspection Districts.	No. of Persons Injured
Jan. 1, 5·0 ...	Cowdenbeath	Scotland, East ...	1
„ 1, 19·30 ...	Gospel Oak	Staffordshire	1
„ 1, 20·30 ...	Netherton (Bridge Pit) ...	Do. ...	1
„ 2, 10·45 ...	Emley Moor	Yorkshire	1
„ 6, 7·30 ...	Gateside	Scotland, West ...	1
„ 8, 5·30 ...	East Plean	Do. ...	1
„ 10, 8·30 ...	Kelty	Scotland, East ...	1
„ 18, 13·15 ...	Ellistown	Midland	1
„ 23, 6·30 ...	Fairlie (No. 3 Pit) ...	Scotland, West ...	3
„ 24, 8·15 ...	Shakenhurst	Staffordshire	2
„ 24, 21·30 ...	Rosehall (No. 5 Pit) ...	Scotland, West ...	2
Feb. 6, 10·0 ...	Eglinton (No. 1 Pit) ...	Do.	1
„ 7, 7·30 ...	Cymmer Glyncorrwg ...	Swansea ...	1
„ 9, 14·30 ...	Clydach Merthyr	Do. ...	1
„ 10, 11·30 ...	Cwm	Cardiff	1
„ 13, 16·30 ...	Glencraig	Scotland, East ...	1
„ 14, 16·0 ...	Ross (No. 1 Pit)	Scotland, West ...	1
„ 17, 7·30 ...	Horseley	Staffordshire	1
„ 18, 3·0 ...	Lochwood (No. 3 Pit) ...	Scotland, West ...	1
„ 19, 3·30 ...	Glangarnant	Swansea	3
„ 19, 19·30 ...	Wharncliffe Gannister ...	Yorkshire	1
„ 23, 23·45 ...	Canderigg (No. 1 Pit) ...	Scotland, West ...	1
„ 24, 0·30 ...	Garw Fechan (No. 2 Pit)	Swansea	1
„ 24, 22·30 ...	Tanfield Lea	Newcastle-upon-Tyne	1
Mar. 7, 16·0 ...	Pantmawr	Swansea	2

TABLE III.—*Continued.*

1902.		Colliery.	Mines-Inspection Districts.	No. of Persons Injured.
Mar.	8, 9·0 ...	Blairhall	Scotland, East ...	1
,,	10, 5·45...	Greenhill	Do. ...	1
,,	11, 12·30...	Dunnikier	Do. ...	2
,,	17, 8·0 ...	Maypole	Liverpool	5
,,	17, 9·30...	Noyadd	Swansea	1
,,	20, 12·0 ..	Woodhall	Scotland, West ...	1
,,	21, 18·30...	Noyadd	Swansea	1
,,	21, 22·0 ...	Allanton (No. 2 Pit) ...	Scotland, West ...	1
,,	26, 10·0 ...	Allanton (No. 2 Pit) ...	Do. ...	1
,,	29, 7·0 ...	Greenfield (No. 7 Pit) ...	Do. ...	2
April	14, 20·0 ...	Duffryn Rhondda	Swansea	1
,,	14, 20·0 ...	Nethercroy No. 3 Pit) ...	Scotland. West ...	1
,,	15, 14·30...	Rigfoot	Do. ...	1
,,	16, 13·0 ...	Lochwood (No. 3 Pit) ...	Do. ...	1
,,	19, 20·0 ...	Clydach Merthyr	Swansea	2
,,	21, 12·45..	Gartshore (No. 9 Pit) ...	Scotland, West ...	1
,,	30, 8·30...	Blackwell	Midland	1
May	2, 23·30...	Crigglestone	Yorkshire	2
,,	6, 6·30...	Mud Hall	Staffordshire	1
,,	9, 6·30...	Greenfield (Threestonehill No. 7 Pit)	Scotland, West ...	1
,,	9, 15·0 ...	Birchrock	Swansea	1
,,	14, 11·15 .	Coneygre (Lye Cross Pit)	Staffordshire	1
,,	16, 7·0 ...	Dillwyn	Swansea	1
,,	17, 6·30...	Caenewydd	Do.	1
,,	26, 14·0 ...	Monkland	Scotland, East ...	1
June	3, 10·0 ...	Donisthorpe	Midland	1
,,	3, 18·0 ...	Braidhurst	Scotland, East ...	1
,,	10, 4·0 ...	Houldsworth	Scotland, West ...	1
,,	11, 16·30...	Stargate	Newcastle-upon-Tyne	1
,,	21, 10·30...	Kilton (ironstone-mine) ...	Durham	1
,,	23, 13·30...	Diamond	Swansea	2
,,	25, 21·0 ...	Skellyton (No. 3 Pit) ...	Scotland, West ...	2
,,	28, 7·15...	Glencraig	Scotland, East ...	1
July	2, 14·30...	Morriston	Swansea	1
,,	4, 7·20...	Avonhead	Scotland, East ...	1
,,	5, 8·50...	Clifton	Midland	1
,,	8, 6·30...	Swalwell	Newcastle-upon-Tyne	1
,,	8, 8·30...	Pantycelyn	Swansea	1
,,	8, 15·30..	Dunston	Newcastle-upon-Tyne	4
,,	9, 6·15...	Machan	Scotland, West ...	1
,,	11, 22·30...	Portland	Midland	1
,,	14, 8·0 ...	Wester Gartshore (No. 1 Pit)	Scotland, West ...	1
,,	21, 3·0 ...	Blaenclydach	Cardiff	2
,,	23, 15·30..	Barglachan (No. 2 Pit) ...	Scotland, West ...	1
,,	26, 6·15 ..	Grange	Staffordshire	1
,,	29, 12·15...	South Hiendley	Yorkshire	1
,,	30, 15·30...	Griff	Midland	1
Aug.	4, 11·0 ...	Cadder (No. 16 Pit) ...	Scotland, West ...	1
,,	6, 14·45...	Cousland (Oil-shale) ...	Scotland, East ...	1
,,	6, 23·30 ..	Hook	Swansea	1
,,	8, 14·0 ...	Eston (ironstone-mine) ...	Durham	3
,,	16, 13·0 ...	Bowhill (No. 2 Pit) ...	Scotland, West ...	1
,,	17, 21·0 ...	Greenfield (Threestonehill No. 7 Pit)	Scotland, West ...	1
,,	18, 15·30 .	Wood Farm (No. 4 Pit) ..	Staffordshire	2
,,	22, 8·30...	Meiros	Cardiff	1
,,	22, 11·30...	Portland (No. 4 Pit) ...	Scotland, West ...	2
,,	22, 15·0 ...	Dalziel	Scotland, East ...	4

TABLE III.—*Continued.*

1902.		Colliery.	Mines-inspection Districts.	No. of Persons Injured.
Aug.	23, 5·30...	Dalziel	Scotland, East ...	1
,,	23, 7·10...	Ibstock	Midland	1
,,	25, 1·30...	Ellismuir (No. 3 Pit) ...	Scotland, West ...	2
,,	26, 11·30...	Wharncliffe Gannister ..	Yorkshire	1
Sept.	3, 8·0 ...	Birkrigg (No. 2 Pit) ...	Scotland, West ...	1
,,	3, 9·0 ...	Rigfoot	Do. ..	1
,,	3, 12·0 ...	Thankerton (No. 4 Pit) ...	Do. ...	2
,,	6, 7·30...	Dumbreck (No. 2 Pit) ...	Do. ...	1
,,	8, 6·0 ...	Main Coal	Liverpool	1
,,	10, 14·30...	Noyadd	Swansea	1
,,	15, 20·0 ...	Onllwyn	Do. ...	1
,,	16, 9·30...	Pye Hill	Midland	1
,,	16, 19·30...	Birchrock	Swansea	2
,,	19, 7·30...	Law	Scotland, East ...	1
,,	22, 9·0 ...	Gartsherrie (Gartcloss Pit)	Scotland, West ...	1
,,	23, 14·30...	Shawsburn	Do.	1
,,	29, 6·30...	Arniston	Scotland, East ..	1
Oct.	6, 21·0 ...	Hazlerigg	Newcastle-upon-Tyne	1
,,	7, 16·0 ...	Onllwyn	Swansea	1
,,	8, 5·45...	Wallyford	Scotland, East ...	1
,,	9, 13·0 ..	Donisthorpe	Midland	1
,,	9, 16·15...	Tower	Cardiff	1
,,	11, 8·0 ...	Donisthorpe	Midland	1
,,	14, 9·30...	Ynyscedwyn	Swansea	2
,,	15, 23·30...	Backworth	Newcastle-upon-Tyne	3
,,	21, 10·0 ...	Exhall	Midland	0
,,	23, 3·0 ...	Duffryn Rhondda	Swansea	1
,,	24, 12·0 ...	Oldnall	Staffordshire	1
,,	26, 10·0 ...	Houldsworth	Scotland, West ...	2
,,	31, 7·30...	Tannochside (No. 3 Pit) .	Do.	2
Nov.	6, 2·0 ...	Bogleshole (No. 4 Pit) ...	Do.	1
,,	6, 9·0 ...	Ross (No. 1 Pit)	Do.	1
,,	8, 19·45...	Wallyford	Scotland, East ...	1
,,	18, 0·0 ...	Cadder (No. 17 Pit) ...	Scotland, West ...	1
,,	20, 12·45..	Swanwick	Midland	1
,,	20, 15·30...	Meiklehill (No. 5 Pit) ..	Scotland, West ...	2
,,	27, 11·0 ...	Wellshot (No. 2 Pit) ..	Do.	1
,,	28, 8·0 ...	Cwmavon	Swansea	2
,,	28, 9·30 ..	Bourtreehill (Capringstone No. 7 Pit)	Scotland, West ...	1
,,	28, 21·0 ...	Pumpherston (Oil-shale) ..	Scotland, East ...	1
,,	29, 9·0 ..	Ellismuir (No. 3 Pit) ..	Scotland, West ...	2
Dec.	1, 22·0 ..	Goatfoot	Do.	1
,,	5, 7·30...	Maritime Level	Cardiff	1
,,	5, 21·0 ..	Seaton Delaval	Newcastle-upon-Tyne	1
,,	9, 7·15...	Waunycoed	Swansea	1
,,	9, 20·30...	Grange	Staffordshire ...	1
,,	12, 7·30 .	Westburn (No. 2 Pit) ...	Scotland, West ..	1
,,	16, 9·15...	North Elswick	Newcastle-upon-Tyne	1
,,	17, 14·0 ...	Bentilee	Staffordshire	2
,,	29, 18·0 ..	Lochwood (No. 3 Pit) ..	Scotland, West .	1
,,	30, 17·30 ..	Brusselton	Durham	1
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TABLE IV.—BAROMETER, THERMOMETER, ETC., READINGS, 1902.

JANUARY, 1902.

	KEW.							GLASGOW.						
	BAROMETER.				TEMPERATURE.			BAROMETER.				TEMPERATURE.		
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon.
1	29·772	29·834	29·651	29·307	52·0	43·3	SW	1	29·491	29·462	29·211	28·765	44·9	39·8	SSW
2	29·189	29·329	29·448	29·663	52·3	45·1	W	2	28 779	28·916	29·192	29·444	47·0	40·9	W
3	29·841	29·986	29·983	30·001	52·3	39·0	SW	3	29·617	29·585	29·572	29·576	51·1	43·2	SW
4	29·963	29·913	29·819	29·942	52·2	43·0	SW	4	29·537	29·503	29·454	29·426	48·6	40·8	WSW
5	30·006	30·117	30·281	30·437	47·3	38·6	W	5	29·615	29·995	30·109	30·060	46·4	40·1	WNW
6	30·421	30·451	30·456	30·550	50·1	39·2	W	6	30·028	30·147	30·233	30·270	49·9	45·4	WNW
7	30·583	30·629	30·618	30·602	46·6	39·4	W	7	30·272	30·217	30·283	30·291	49·4	45·5	W
8	30 565	30·536	30·442	30·352	44·3	41·6	W	8	30·256	30·229	30·138	30·006	46·9	42·9	SW
9	30·257	30·217	30·162	30·156	50·7	41·0	SW	9	29·813	29·666	29·6s5	29·758	48·1	43·8	WSW
10	30·121	30·089	30·043	30·058	52·8	47·7	SW	10	29·756	29·774	29·782	29·900	44·8	36·0	WNW
11	30·039	30·128	30·170	30·181	50·7	41·6	NE	11	29·985	30·102	30·135	30·125	37·0	32·3	N
12	30·125	30·099	30·048	30·097	49·0	41·0	S	12	30·006	29·967	29·971	30·157	39·4	29·2	W
13	30·179	30·298	30·352	30·440	43·1	33·7	NE	13	30·248	30·347	30·415	30·506	33·4	23·7	ESE
14	30·506	30·619	30·673	30·792	35·7	28·3	NE	14	30·565	30·652	3o·647	30·675	28·9	20 8	SW
15	30·839	30·848	30·785	30·720	38·0	24·1	W	15	30·558	30·508	30·474	30·462	47·6	25·3	W
16	30·655	30·665	30·681	30·642	44·3	39·0	W	16	30·440	30·494	30·504	30·536	49·1	46·3	W
17	30·600	30·532	30·440	30·379	44·8	40·3	W	17	30·472	30·410	30·305	30·275	46·6	39·9	W
18	30·430	30·346	30·330	30·377	44·0	31·1	N	18	30·245	30·252	30·223	30·215	42·1	38·3	SW
19	30·398	30·436	30·370	30·341	41·8	27 0	N	19	30·146	30·063	29·973	29·833	44·6	39·4	W
20	30·269	30·264	30·231	30·279	49·7	41·6	WSW	20	30·735	29·794	29·892	29·966	49·3	43·7	W
21	30·292	30·324	30·323	30·372	51·1	45·2	W	21	29·980	30·035	30·065	30·068	48 6	43·1	WSW
22	30·342	30 330	30·267	30·268	51·9	47·5	W	22	30·060	30·102	30·085	30·023	49·1	42·8	W
23	30·230	30·203	30·093	29·959	48·2	42·2	WSW	23	29·973	29·904	29·729	29·550	48·5	45·1	SW
24	29·694	29·431	29·256	29·207	47·0	36·0	S	24	29·232	29·056	28·971	28·960	45·9	32·5	WSW
25	29 116	29·197	29·275	29·446	39·2	31·9	W	25	28·943	28·978	29·164	29·472	38·1	30·7	W
26	29·673	29·811	29·813	29·722	38·7	32·1	W	26	29·575	29·622	29·624	29·578	32·1	25·9	NW
27	29·547	29·443	29·505	29·486	47·6	35·0	W	27	29 463	29·454	29·339	29·150	30·3	25·8	E
28	29·274	29·198	29·214	29·562	44·5	35·5	SW	28	29·029	29·154	29·443	29·670	36·9	28·3	NNE
29	29·785	30·007	30·120	30·180	38·0	29·6	NNW	29	29·814	29·840	30·066	30·282	34·3	24·1	N
30	30·263	30·417	30·516	30·619	38·1	29·9	N	30	30·433	30·588	30·673	30·s21	28·5	16·3	W
31	30·628	30·595	30·373	30·330	37·5	34·3	NE	31	30·915	30·969	3o·958	30·982	34·7	14·8	ENE

FEBRUARY, 1902.

1	30·628	30·595	30·373	30·330	38·8	32·5	NE	1	30·952	30·930	30·811	30·732	37·9	28·4	E
2	30·190	30·162	30·072	30·065	34·9	31·5	NE	2	30·607	30·538	30·436	30·391	40·0	36·9	E
3	30·050	30·044	30·022	30·074	35·3	32·5	NE	3	30·303	30·277	30·198	30·229	41·3	37·1	E
4	30·073	30·111	30·094	30·096	35·6	32·8	NE	4	30·209	30·212	30·116	30·061	38·9	34·1	ESE
5	30·043	30·020	29 889	29·797	36·4	32·2	ESE	5	29·967	29·870	29·721	29·596	35·3	28·9	SW
6	29·620	29·514	29·403	29·366	38·3	32·9	NNE	6	29·464	29·390	29·303	29·326	38·6	33·8	SW
7	29·348	29·413	29·441	29·455	38·8	31·7	N	7	29·356	29·419	29·417	29·418	36·1	29·5	ENE
8	29·380	29·328	29·352	29·338	37·3	32·0	ESE	8	29·398	29·435	29·420	29·380	33·3	24·2	ENE
9	29·363	29·478	29·475	29·523	38·9	30·1	W	9	29·301	29·329	29·369	29·485	38·1	24·8	W
10	29·531	29·547	29·550	29·634	34·4	27·3	NE	10	29·520	29·538	29·526	29·547	35·0	26·1	W
11	29·704	29·771	29·790	29·856	39·2	24·4	W	11	29·557	29·649	29·721	29·782	33·2	26·4	W
12	29·884	29·940	29·911	29·921	37·0	24·0	N	12	29·745	29·802	29·847	29·892	34·7	26·2	NW
13	29·887	29·913	29·896	29·969	37·2	20·6	N	13	29·907	29·973	29·984	30·040	34·1	20·3	SSE
14	29·992	30·073	30·088	30·135	33·7	27·4	N	14	30·003	29·941	29·967	30·083	41·1	18·3	W
15	30·139	30·246	30·322	30·399	36·1	22·7	NNE	15	30·136	30·163	30·112	30·078	39·5	26·9	SSW
16	30·377	30·296	30·160	30·061	36·2	17·7	ESE	16	29·991	29·952	29·877	29·865	40·1	35·1	SSW
17	29·927	29·929	29·900	29·976	40·0	21·0	NE	17	29·832	29·888	29·904	30·000	38·9	30·4	N
18	29·987	30·036	30·011	30·037	36·0	31·9	NE	18	30·010	30·032	29·974	29·982	37·1	28·6	ENE
19	30·029	30·059	30·049	30·087	36·4	33·7	ESE	19	29·971	30·010	30·021	30·076	40·3	35·4	E
20	30·073	30·081	30·046	30·069	37·1	33·9	E	20	30·097	30·109	30·052	30·010	38·3	35·6	S
21	30·051	30·061	30·017	30·022	47·0	34·3	E	21	29·934	29·912	29·858	29·827	37·4	34·3	S
22	29·971	29·945	29·850	29·807	49·1	33·1	SSE	22	29·739	29·703	29·630	29·568	42·5	37·2	ESE
23	29·745	29·759	29·741	29·726	50·3	43·7	S	23	29·498	29·560	29·547	29·515	48·0	38·2	NNE
24	29·668	29·632	29·607	29·638	48·0	43·8	SE	24	29·497	29·509	29·511	29·566	49·8	44·3	SE
25	29·627	29·628	29·613	29·634	47·7	38·9	E	25	29·588	29·629	29·605	29·617	46·9	40·6	ENE
26	29·594	29·565	29·433	29·275	47·1	37·8	E	26	29·580	29·562	29·436	29·341	42·1	33·3	E
27	29·226	29·248	29·252	29·318	49·8	42·0	SW	27	29·206	29·189	29·179	29·216	37·4	33·9	E
28	29·350	29·478	29·493	29·554	52·6	39·2	SW	28	29·214	29·233	29·290	29·380	38·9	34·9	E

MARCH, 1902.

Date.	KEW. Barometer. 4 A.M.	10 A.M.	4 P.M.	10 P.M.	Temperature. Max	Min.	Direction of wind at noon.	Date.	GLASGOW. Barometer. 4 A.M.	10 A.M.	4 P.M.	10 P.M.	Temperature. Max	Min.	Direction of wind at noon.
1	29·557	29·602	29·629	29 727	51·6	35·6	SW	1	29·416	29·484	29·506	29·555	47·2	36 3	SSE
2	29·771	29·862	29·851	29·967	53·1	34·0	SSE	2	29·582	29·660	29·736	29·780	47·4	41·9	SW
3	29·986	30·032	29·999	(9·040	51·3	37·2	SW	3	29·758	29·714	29·655	29·719	46·9	39·1	S
4	30·037	30·060	30·020	30·074	46·9	37·2	SE	4	29·759	29·825	29·857	29 897	49·9	43·3	SW
5	30·063	30·095	30·043	30·060	47·0	35·2	E	5	29·870	29·873	29·929	29·931	47·6	42 2	WSW
6	30·024	30·038	29·934	29 937	51·9	31·7	NW	6	29·876	29·877	29·834	29·833	46·5	42·9	WSW
7	29·904	29·928	29·903	29·947	51·9	30·0	W	7	29·831	29·879	29·870	29·871	52·1	42·6	NNW
8	29·938	29·888	29·822	29·775	51·3	42 7	W	8	29·768	29 686	29·544	29·459	48·1	43 3	W
9	29·702	29·768	29·839	29·906	55·1	46·9	NW	9	29·545	29·687	29·721	29·732	48·4	42 7	W
10	29·895	29·960	29·963	30·000	49·7	43·7	E	10	29·765	29·840	29·873	29·929	51 ·	43 3	W
11	29·988	30·006	29·988	30·013	49·9	40·6	SSW	11	29·948	29·987	29·947	29·942	46·4	39·9	E
12	30·020	30·039	29·991	30·035	53·7	40·7	S	12	29·882	29·834	29·737	29·795	47·9	39·6	SSW
13	30·031	30·050	30·012	30·045	55·1	35·8	S	13	29·738	29·645	29·704	29·760	48·1	34·9	SW
14	30·024	29·990	29·831	29·535	53·0	39·2	SSW	14	29·742	29·709	29·604	29·532	48·4	39·0	SW
15	29·595	29·817	29·903	30·014	52·8	42·8	WNW	15	29·540	29·643	29·739	29·860	47·2	38·2	WNW
16	30·035	30·120	30·133	30·207	54·2	40·9	NW	16	29·940	30·029	30·048	30·042	50·5	37·3	W
17	30·195	30·218	30·170	30·172	59·2	39·9	W	17	30·007	30 002	29·959	29·891	51·3	45 8	SW
18	30·101	30·091	30·008	29·989	50·6	43·0	SW	18	29·769	29·684	29·616	29·694	49·1	42 9	SW
19	29·931	29·911	29·793	29·674	55·1	41·8	W	19	29·669	29·598	29·349	28·905	44·9	38·4	WSW
20	29 473	29·363	29·284	29·408	49·7	40·0	WSW	20	28·916	28·927	28·905	28·917	44·6	33·6	W
21	29·291	29·271	29·228	29·250	50·1	37·9	SW	21	28·902	28·933	28·952	29·009	42·3	31·8	WSW
22	29·228	29·263	29·294	29·367	46·6	35·7	W	22	28·988	29·023	29·047	29·142	44·8	34·2	WSW
23	29·367	29·416	29·442	29·540	49·1	31·8	W	23	29·202	29·305	29·360	29·441	44·1	34·6	N
24	29·578	29·551	29·288	29·082	46·6	32·5	S	24	29·397	29·283	29·147	29·223	44·1	29·4	ESE
25	29·196	29·521	29·697	29·846	48·6	35·2	NW	25	29·387	29·522	29·606	29·659	43 4	31·3	WNW
26	29·899	29·964	29·953	29·851	47·4	32·6	W	26	29·670	29·707	29·705	29·643	41·8	31·5	W
27	29·663	29·723	29·736	29·854	57·7	39·8	W	27	29 575	29·573	29·643	29·719	46·0	34·1	ENE
28	29·882	29·911	29·911	29·968	56·3	43·3	W	28	29 712	29·767	29·800	29·772	47·1	37·5	NNE
29	29·874	29·735	29·577	29·709	55·8	41·4	SW	29	29·581	29·356	29·575	29·786	49 5	38·8	N
30	29·917	29·946	29·893	29·925	55·0	36·5	SW	30	29·815	29·845	29·805	29·767	43·4	34·2	W
31	29·878	29·862	29·796	29·737	60 0	43·2	W	31	29·633	29·598	29·525	29·463	50·1	37·1	W

APRIL, 1902.

1	29·621	29·576	29·535	29·665	55·1	42·0	SW	1	29·563	29·538	29·418	29·531	45·9	37 4	W
2	29·727	29·817	29·815	29·849	50·1	38·6	NNE	2	29·502	29·680	29·663	29·621	48·1	34·9	WNW
3	29·813	29·795	29·689	29·680	52·7	36·9	SW	3	29·502	29·481	29·415	29·481	42·8	35·9	W
4	29·812	29·893	29·926	29·961	51·9	35·7	W	4	29·440	29·597	29·702	29·770	46·3	33·5	WNW
5	29·931	29·939	29·708	29·737	52·7	39·0	SW	5	29·777	29·812	29·873	29·974	46·4	33·2	ESE
6	29·855	30·016	30·115	30·230	47·7	35·7	N	6	30·071	30·151	30·190	30·252	46·8	35 4	ESE
7	30·275	30·317	30·285	30·285	45·1	32·1	NE	7	30·267	30·285	30·237	30·224	47·6	36·2	WSW
8	30·232	30·227	30·150	30·156	44·0	36·0	E	8	30·182	30·171	30·124	30·159	46·3	31·3	NNE
9	30·129	30·139	30·091	30·114	47·4	35·3	ENE	9	30·167	30·185	30·145	30·161	52·3	33·1	ENE
10	30·074	30·058	29·995	29·996	46·2	36·3	NE	10	30·176	30·181	30·117	30·160	52·4	36·3	E
11	29·915	29·859	29·742	29·731	48·1	36·6	NE	11	30·109	30·027	29·893	29·871	44·2	36·2	ESE
12	29·709	29·733	29·740	29·804	52·3	40·2	S	12	29·779	29·740	29·685	29·698	43·0	37·3	ENE
13	29·850	29·931	29·920	29·979	56·3	37·8	NW	13	29·930	29·954	29·974	30·745	45·0	33·3	S
14	29·970	29·964	29·842	29·817	55·0	32·8	E	14	29·768	29·780	29·780	29·787	52·6	35·2	S
15	29·704	29·615	29·575	29·667	59·7	44·3	E	15	29·770	29·756	29·671	29·666	52·1	37 5	E
16	29·777	29·851	29·849	29·871	59·0	44·2	NW	16	29·706	29·799	29·817	29·848	55·3	38·1	NNW
17	29·873	29·913	29·915	29·982	60·3	40·9	W	17	29·826	29·856	29·833	29·893	54·8	42·7	NW
18	29·991	30·016	29·950	29·963	61·0	40·3	S	18	29·882	29·888	29·845	29·828	56·7	36·4	SSE
19	29·889	29·848	29·804	29·870	65·6	42·3	SSE	19	29·760	29·716	29·692	29·622	58·1	42·0	E
20	29·872	29·900	29·921	29·969	61·1	46·0	SW	20	29·661	29·656	29·627	29·631	58·1	47·4	SE
21	30·009	30·036	29·998	29·849	60·2	47·3	S	21	29·642	29·663	29·670	29·691	56·0	47·6	W-W
22	29·894	29·527	29·542	29·648	58·3	47·7	S	22	29·378	29·272	29·162	29·254	55·8	46·9	FSE
23	29·711	29·767	29·827	29·914	60·2	45·0	SSW	23	29·400	29·528	29·611	29·716	55·5	45·9	S-W
24	29·982	30·070	30·078	30·124	63·4	41·7	S	24	29·776	29·787	29·951	30·011	55·7	44·0	SW
25	30·092	30·048	29·954	29·927	64·5	38·7	ESE	25	30·038	30·058	29·992	30·042	58·6	42·3	NE
26	29·861	29·852	29·808	29·862	55·3	44·4	ENE	26	30·068	30·107	30·106	30·160	51·8	42·3	E
27	29·860	29·909	29·926	30·017	55·1	43·6	ENE	27	30·176	30·222	30·246	30·281	48·9	37·4	F
28	30·038	30·087	30·071	30·153	52·7	38·7	NE	28	30·302	30·298	30·262	30·273	52·2	35·8	ENE
29	30·171	30·209	30·173	30·158	51·0	35·9	N	29	30·256	30·199	30·086	29·981	53·7	36·8	WNW
30	30·085	29·990	29·884	29·815	55·2	40 0	WNW	30	29·934	29·845	29·712	29·653	50·8	43·1	WSW

MAY, 1902.

KEW.								GLASGOW.							
	BAROMETER.				TEMPERATURE.				BAROMETER.				TEMPERATURE.		
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon.
1	29·672	29·691	29·705	29·800	54·7	40·2	NW	1	29·627	29·678	29·676	29·666	53·1	39·9	NW
2	29·798	29 747	29·663	29·659	57·8	35·9	W	2	29·554	29·474	29·424	29·425	51·8	39·5	W
3	29·623	29·580	29·515	29·665	54·1	41·2	W	3	29·404	29·480	29·572	29·713	50·0	35·8	N
4	29·753	29·884	29·929	30·040	53·3	39·3	N	4	29·827	29·905	29·906	29·881	51·6	38·0	NW
5	30·036	29·999	30·045	30·163	52·8	36·0	WNW	5	29·952	30·056	30·064	30·174	48·9	36·4	WNW
6	30·158	30·200	30·159	30·170	49·3	35·3	NW	6	30·202	30·203	30·161	30·248	48·6	33·1	NW
7	30·158	30·187	30·169	30·224	49·9	34·9	N	7	30·263	30·287	30·271	30·316	55·1	38·0	NNE
8	30·190	30·205	30·188	30·247	51·1	38·9	N	8	30·316	30·321	30·287	30·270	51·7	37·5	NE
9	30·210	30·175	30·095	30·137	50·9	36·4	E	9	30·207	30·190	30·175	30·244	51·4	41·1	E
10	30·131	30·125	30·063	30·059	51·0	34·8	N	10	30·231	30·160	30·055	30·010	54·7	32·8	W
11	30·014	29·991	29 921	29·898	53·3	40·0	NE	11	29·952	29·917	29·875	29·881	53·1	41·9	N
12	29·833	29·826	29·816	29·913	54·3	39·9	N	12	29·902	29·943	29·935	29 981	51·1	41·3	NE
13	29·922	29·919	29·896	29·918	48·4	35·9	N	13	29·947	29·933	29·873	29·886	50·3	36·3	N
14	29·903	29·881	29·857	29·874	52·1	32·3	WNW	14	29·888	29·873	29·823	29·756	48·4	35·8	NNW
15	29·801	29 744	29·631	29·592	55·3	34·2	S	15	29·641	29·571	29·524	29·575	45·1	39·8	ESE
16	29·571	29·649	29·536	29·500	55·4	48·4	WSW	16	29·571	29·496	29·363	29·237	46·4	37·7	SSW
17	29·467	29·452	29·295	29·253	57·2	44·2	WSW	17	29·106	29·161	29·126	29·275	54·2	41·2	WNW
18	29·291	29·518	29·558	29·598	54·6	43·1	W	18	29 408	29·495	29·604	29·761	49·5	37·6	ENE
19	29·680	29·774	29·821	29·891	53·0	41·3	NNW	19	29·825	29·863	29·890	29·948	51·1	39·8	NNW
20	29·903	29·961	30·033	30·122	49·2	41·0	NNW	20	29·996	30·048	30·091	30 179	53·2	35·2	NNE
21	30·186	30·261	30·293	30·335	55·6	43·1	N	21	30·215	30·235	30·237	30·223	53·4	35·0	W
22	30 322	30·313	30·247	30·177	55·9	42·9	W	22	30·126	30·093	30·070	30·075	52·3	43·6	W
23	30·170	30·234	30·293	30·363	60·3	51·1	NNE	23	30·137	30·198	30·261	30·322	59·4	50·2	W
24	30·365	30·388	30·364	30·397	70·0	49·4	NW	24	30·320	30·295	30·236	30·266	57·8	49·6	WSW
25	30·395	30·435	30·383	30·382	66·4	51·1	NNW	25	30·276	30·284	30·243	30·239	54·4	44·8	WNW
26	30·354	30·329	30·232	30·186	68·5	47·1	W	26	30·203	30·142	30·005	29·965	52·1	47·9	WSW
27	30·126	30·064	29·929	29·888	69·8	50·0	WSW	27	29·968	29·754	29·559	29·417	57·3	49·1	SW
28	29·769	29·720	29·695	29·717	65·1	48·9	WSW	28	29·333	29·343	29·410	29·511	52·8	43·9	W
29	29·739	29·817	29·800	29·792	62·6	49·9	W	29	29·568	29·702	29·772	29·826	55·7	38·9	WNW
30	29·684	29·652	29·594	29·574	63·3	48·1	NE	30	29·826	29·829	29·820	29·860	52·4	41·4	E
31	29·605	29·668	29·695	29·715	70·2	54·1	SE	31	29·825	29·835	29·920	30·020	46·8	42·8	E

JUNE, 1902.

1	29·686	29·683	29·691	29·873	73·6	54·0	E	1	30·009	30·010	29·981	29·933	51·2	43·4	E
2	29·9·7	30·082	30·068	30·085	70·3	51·6	SSE	2	29·909	30·012	30·042	30·110	59·1	45·9	E
3	30·058	30·052	30·034	30·072	75·2	51·4	NW	3	30·121	30·075	29·979	30·023	61·1	47·5	E
4	30·064	30·023	30·030	30·061	62·9	54·9	SW	4	30·001	29·976	29·918	29 901	59·1	47·0	W
5	30 052	30·061	30·025	30·019	66·0	52·9	WSW	5	29·858	29·841	29·803	29·787	62·4	50·7	SW
6	29·967	29·883	29·697	29·639	59·3	50·7	SW	6	29·732	29·658	29·519	29·471	57·1	47·9	WNW
7	29·566	29·510	29·411	29·547	59·4	47·3	WSW	7	29·427	29·505	29·514	29·567	54·9	43·9	E
8	29·586	29·635	29·660	29·715	57·0	46·7	W	8	29·632	29 719	29·749	29·788	51·8	45·9	ESE
9	29·730	29·752	29·758	29·807	53·9	45·0	N	9	29·792	29·791	29·791	29·834	53·2	43·8	NE
10	29·812	29·820	29·800	29·817	57·1	40·1	N	10	29·834	29·803	29·723	29·719	57·9	40·5	NW
11	29·794	29·781	29·732	29·718	60·9	46·2	SSW	11	29·677	29·646	29·596	29·594	51·1	43·9	WNW
12	29·599	29·562	29·454	29·371	56·8	49·1	SE	12	29·532	29·517	29·483	29·496	52·2	44·9	W
13	29·323	29·407	29·486	29·596	54·0	48·2	W	13	29·500	29·547	29·575	29 587	58·3	47·5	ENE
14	29·645	29·724	29·692	29·694	55·8	48·3	W	14	29·608	29·618	29·587	29·609	55·7	45·3	WNW
15	29·672	29·681	29·676	29·699	57·9	47·4	WSW	15	29·603	29·651	29·705	29·765	56·0	47·8	ENE
16	29·685	29·703	29·713	29·787	57·5	48·0	S	16	29·785	29·823	29·861	29·920	52·5	48·1	E
17	29·828	29·947	29·992	30·083	61·0	45·0	N	17	29·942	30·000	30·034	30·086	54·3	44·5	ESE
18	30·102	30·122	30·062	30·025	64·9	45·8	ESE	18	30·076	30·060	29·975	29·919	57·6	45·0	E
19	29·925	29·820	29·665	29·590	70·8	48·7	SE	19	29·841	29·779	29·666	29·662	65 9	47·0	E
20	29·524	29·576	29·608	29·687	64·8	54·3	SW	20	29·617	29·641	29·682	29·721	58·4	48·9	ENE
21	29·753	29·849	29·925	30·047	66·9	54·2	WSW	21	29·754	29·798	29·864	29·925	51·3	47·1	ENE
22	30·101	30·135	30·131	30·139	68·1	49·8	SW	22	29·941	29·955	29·927	29·922	61·3	45·6	SSW
23	30·140	30·166	30·160	30·205	74·2	54·8	SW	23	29·963	30·041	30·077	30·133	66·8	54·1	WNW
24	30·225	30·232	30·205	30·229	78·4	54·9	SSE	24	30·139	30·178	30·171	30·167	72·2	55·3	WNW
25	30·231	30·208	30·149	30·146	70·7	58·2	E	25	30·171	30·141	30·107	30 117	81·8	55·9	SSW
26	30·134	30·125	30·089	30·124	73·0	56·0	ENE	26	30·151	30·165	30·110	30·159	73·5	50·3	SE
27	30·140	30·171	30·157	30·171	77·6	56·2	E	27	30·214	30·223	30·171	30·182	77·2	48·1	NE
28	30·131	30·088	30·014	29·992	80·1	57·2	E	28	30·180	30·179	30·128	30 172	71·7	52·1	E
29	29·934	29·931	29·956	30·017	77·9	57·9	S	29	30·139	30·118	30·041	30·030	62·1	50·7	F
30	29·996	29·981	29·880	29·873	80·5	54·1	SE	30	29·959	29·925	29·864	29·857	71·9	50·6	W

JULY, 1902.

KEW.

Date.	Barometer. 4 A.M.	10 A.M.	4 P.M.	10 P.M.	Temperature. Max	Min.	Direction of wind at noon.
1	29·846	29·882	29·881	30·004	72·9	51·9	SW
2	30·083	30·198	30·230	30·286	61·3	49·0	SE
3	30·272	30·270	30·203	30·183	67·2	46·6	SW
4	30·123	30·110	30·067	30·124	76·5	49·0	SW
5	30·146	30·181	30·139	30·178	78·1	59·5	W
6	30·184	30·166	30·096	30·094	79·1	59·4	S
7	30·075	30·098	30·093	30·129	78·6	60·0	NW
8	30·149	30·149	30·069	30·063	81·1	56·6	SW
9	30·000	29·933	29·812	29·759	71·7	55·7	SW
10	29·698	29·646	29·641	29·797	63·8	53·2	WSW
11	29·941	30·066	30·123	30·195	63·2	51·3	WNW
12	30·201	30·187	30·121	30·126	70·4	45·6	W
13	30·101	30·107	30·050	30·064	77·4	52·9	SW
14	30·052	30·038	29·988	30·000	83·0	52·4	SE
15	29·981	29·968	29·945	30·000	81·7	56·5	WSW
16	30·029	30·003	29·954	29·980	73·2	57·3	N
17	29·979	30·007	29·987	30·019	72·5	53·7	NW
18	30·025	30·052	30·016	30·075	65·2	50·9	NW
19	30·067	30·031	29·926	29·895	64·7	46·6	NW
20	29·815	29·846	29·862	29·910	57·8	50·4	NE
21	29·875	29·923	29·958	29·988	56·9	49·7	NNW
22	29·941	29·945	29·905	29·871	58·5	50·8	SW
23	29·859	29·903	29·900	29·895	69·2	52·3	N
24	29·849	29·816	29·796	29·839	67·4	53·8	SW
25	29·860	29·906	29·894	29·859	68·1	55·0	SW
26	29·650	29·550	29·478	29·459	71·1	55·8	SSW
27	29·493	29·590	29·784	29·968	62·9	51·4	W
28	30·054	30·124	30·129	30·174	68·1	49·7	WSW
29	30·152	30·148	30·122	30·141	68·0	51·0	W
30	30·126	30·119	30·079	30·088	65·4	50·8	W
31	30·050	30·072	30·068	30·109	64·1	53·0	WNW

GLASGOW.

Date.	Barometer. 4 A.M.	10 A.M.	4 P.M.	10 P.M.	Temperature. Max	Min.	Direction of wind at noon.
1	29·867	29·952	29·985	30·067	63·2	49·8	E
2	30·110	30·165	30·149	30·154	64·7	49·0	W
3	30·091	30·062	29·996	29·935	60·3	52·6	SW
4	29·837	29·862	29·926	30·029	67·1	56·3	WSW
5	30·105	30·142	30·133	30·117	71·6	49·1	W
6	30·070	30·011	29·988	29·992	64·6	53·5	W
7	29·982	30·015	30·050	30·068	60·1	53·9	W
8	30·042	29·999	29·878	29·857	59·9	53·5	WSW
9	29·781	29·676	29·548	29·501	61·1	53·2	W
10	29·454	29·519	29·673	29·836	59·1	50·0	N
11	29·948	30·042	30·070	30·093	60·3	44·3	W
12	30·049	29·959	29·861	29·843	57·3	44·1	SW
13	29·855	29·892	29·897	29·923	61·9	53·9	SW
14	29·911	29·935	29·943	29·927	63·3	56·9	SW
15	29·877	29·893	29·934	29·991	65·4	55·9	W
16	29·967	29·995	29·957	29·927	61·7	52·1	SW
17	29·860	29·877	29·901	29·943	59·8	50·9	W
18	29·966	30·015	30·027	30·049	59·8	44·8	NW
19	30·015	29·949	29·899	29·977	59·9	47·9	WSW
20	30·008	30·017	29·982	29·997	59·2	45·7	N
21	29·979	29·966	29·890	29·858	61·8	45·6	SW
22	29·807	29·816	29·818	29·846	60·3	48·1	NE
23	29·845	29·834	29·799	29·770	64·5	48·1	SW
24	29·710	29·714	29·714	29·758	59·2	46·3	W
25	29·779	29·792	29·807	29·766	59·3	42·1	WSW
26	29·611	29·387	29·259	29·215	54·1	47·2	E
27	29·209	29·481	29·614	29·773	60·9	50·2	NW
28	29·839	29·902	29·938	29·899	61·3	47·3	W
29	29·855	29·898	29·928	29·963	59·6	50·9	WNW
30	29·927	29·959	29·969	30·006	59·3	49·2	NW
31	30·025	29·969	30·079	30·106	58·4	45·2	NE

AUGUST, 1902.

1	30·123	30·158	30·109	30·108	64·8	50·0	N
2	30·031	29·997	29·928	29·873	66·5	46·8	W
3	29·825	29·843	29·855	29·875	65·8	52·9	NW
4	29·863	29·858	29·826	29·845	64·6	52·4	W
5	29·848	29·898	29·896	29·945	73·6	55·4	S
6	29·881	29·821	29·737	29·729	67·9	57·2	S
7	29·761	29·722	29·736	29·788	68·3	57·0	SW
8	29·781	29·787	29·867	30·040	65·5	52·8	N
9	30·105	30·136	30·133	30·130	60·8	48·3	WSW
10	30·059	30·004	29·959	30·000	63·8	49·0	W
11	29·994	30·039	30·032	30·047	60·6	44·4	NW
12	29·983	29·989	29·998	30·028	64·6	49·7	NW
13	29·998	29·981	29·942	29·908	63·6	48·7	W
14	29·878	29·896	29·892	29·941	68·9	56·6	WNW
15	29·954	29·988	29·953	29·943	71·3	55·9	S
16	29·881	29·832	29·714	29·656	76·5	51·3	S
17	29·644	29·706	29·715	29·765	67·5	59·0	S
18	29·780	29·776	29·676	29·625	65·3	57·7	S
19	29·621	29·686	29·683	29·753	70·1	58·6	SW
20	29·810	29·853	29·876	29·951	65·9	50·6	SW
21	29·991	30·083	30·113	30·165	66·0	51·6	N
22	30·183	30·191	30·127	30·114	71·6	47·4	SSW
23	30·023	29·977	29·943	29·897	66·8	56·4	SW
24	29·816	29·813	29·791	29·860	69·6	56·9	W
25	29·910	29·970	29·969	30·024	67·2	51·6	NW
26	30·022	29·995	29·924	29·901	68·9	51·0	SE
27	29·832	29·841	29·824	29·895	68·5	50·1	SW
28	29·910	29·911	29·864	29·865	74·3	49·0	E
29	29·806	29·770	29·675	29·637	76·5	55·3	E
30	29·598	29·642	29·751	29·830	62·8	56·3	NW
31	29·804	29·782	29·756	29·827	66·3	56·9	E

1	30·096	30·094	30·025	29·949	60·8	45·0	W
2	29·786	29·721	29·667	29·664	59·2	50·2	WSW
3	29·660	29·675	29·697	29·735	58·5	49·8	W
4	29·749	29·764	29·773	29·836	64·4	49·5	NW
5	29·866	29·921	29·932	29·960	58·5	51·4	NE
6	29·919	29·886	29·835	29·820	54·6	47·1	E
7	29·802	29·824	29·834	29·863	54·7	49·9	ESE
8	29·872	29·911	29·907	29·949	60·7	48·2	W
9	29·965	30·012	30·008	29·959	59·4	49·4	W
10	29·899	29·948	29·930	29·971	57·7	48·9	W
11	29·952	29·950	29·949	29·943	59·1	43·9	WNW
12	29·932	29·964	29·947	29·955	65·9	44·6	W
13	29·918	29·896	29·867	29·869	61·9	48·8	NE
14	29·865	29·879	29·879	29·919	65·9	50·3	SW
15	29·905	29·912	29·856	29·846	69·6	49·7	WSW
16	29·798	29·783	29·770	29·765	66·1	52·8	W
17	29·717	29·711	29·640	29·558	56·0	51·9	E
18	29·506	29·487	29·404	29·458	63·4	51·9	NNW
19	29·474	29·572	29·609	29·657	59·4	49·7	E
20	29·603	29·634	29·726	29·841	60·1	48·2	WNW
21	29·914	29·987	30·024	30·026	57·3	44·5	SW
22	29·955	29·910	29·849	29·754	65·4	50·9	SW
23	29·678	29·706	29·702	29·695	65·3	56·2	SW
24	29·675	29·685	29·683	29·746	62·9	52·6	WSW
25	29·787	29·853	29·867	29·920	62·3	51·8	W
26	29·920	29·916	29·860	29·844	64·7	49·4	SW
27	29·803	29·809	29·802	29·851	60·7	47·3	E
28	29·852	29·841	29·786	29·794	64·1	51·3	SW
29	29·760	29·798	29·782	29·795	60·3	49·5	W
30	29·785	29·777	29·752	29·781	59·1	52·0	NNW
31	29·778	29·782	29·756	29·775	60·6	46·5	ENE

SEPTEMBER, 1902.

KEW.								GLASGOW.							
	BAROMETER.				TEMPERATURE.				BAROMETER.				TEMPERATURE.		
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon
1	29·836	29·851	29·825	29·867	71·2	56·0	S	1	29·761	29·742	29·658	29·612	62·6	47·3	ENE
2	29·840	29·840	29·748	29·664	67·8	54·6	S	2	29·556	29·591	29·561	29·532	61·8	56·4	SW
3	29·544	29·584	29·744	29·828	68·7	58·4	SW	3	29·271	28·986	29·212	29·365	66·6	53·6	SW
4	29·832	29·875	29·889	29·925	68·6	55·9	SW	4	29·394	29·473	29·654	29·825	56·1	51·8	WSW
5	29·948	30·018	30·013	30·050	66·9	53·9	W	5	29·881	29·929	29·930	29·927	60·7	47·3	WNW
6	30·049	30·054	30·025	30·084	67·3	48·7	SW	6	29·902	29·913	29·946	30·038	63·6	54·3	SW
7	30·100	30·170	30·166	30·218	68·1	44·8	SW	7	30·076	30·139	30·154	30 193	62·4	55·9	SW
8	30·214	30·215	30·146	30·127	68·2	45·6	E	8	30·203	30·202	30·158	30·135	63·9	49·5	W
9	30·031	30·001	29·921	29·953	68·0	53·9	E	9	30·089	30·080	30·033	30·089	62·9	43·4	ENE
10	29·925	29·958	29·919	29·926	66·2	56·3	E	10	30·090	30·109	30·071	30·070	53·3	46·8	E
11	29·853	29·835	29·770	29·752	64·9	55·7	E	11	30·007	29·996	29·926	29·876	53·6	43·9	E
12	29·690	29·688	29·648	29·780	58·9	48·0	N	12	29·713	29·626	29·757	29·917	57·9	43·8	NNE
13	29·921	30·022	29·997	29·969	55·2	41·0	NW	13	29·968	29·952	29·818	29·704	53·3	35·0	NNW
14	29·857	29·821	29·819	29·915	60·2	46·3	W	14	29·631	29·681	29·700	29·721	58·5	49·8	WNW
15	29·924	29·956	29·890	29·817	61·1	52·9	WSW	15	29·652	29·569	29·485	29·415	54·7	50·8	SW
16	29·724	29 694	29·710	29·778	63·7	50·1	W	16	29·341	29·355	29·482	29·602	56·5	47·8	W
17	29 819	29·911	29·976	30·100	59·7	46·0	NW	17	29·681	29·792	29·876	29·998	56·7	45·5	WNW
18	30·147	30·218	30·238	30·299	58·8	41·7	NW	18	30·066	30·117	30·135	30·202	57·1	42·9	W
19	30·326	30·376	30·336	30·352	62·6	37·0	SE	19	30·245	30·305	30·278	30·273	55·4	41·3	E
20	30·305	30·286	30·206	30·225	63·3	41·1	SE	20	30·207	30·193	30·111	30·111	56·1	48·1	SW
21	30·202	30·222	30·151	30·137	66·4	49·7	E	21	30·074	30·075	30·052	30·024	55·5	50·8	E
22	30·063	30·068	30·017	30·009	73·7	53·8	E	22	29·932	29·881	29 874	29 904	61·9	52·1	S
23	29·911	29·864	29·805	29·877	69·3	57·0	SE	23	29·798	29·757	29·644	29·628	60·7	55·7	SE
24	29·957	30·068	30·098	30·197	63·5	46·7	WSW	24	29·774	29·947	30·067	30·158	59·7	49·9	WSW
25	30·270	30·348	30·359	30·420	64·0	42·7	NNE	25	30·199	30·252	30·281	30·347	56·4	44·6	SW
26	30·427	30·454	30·396	30·426	65·3	40·6	ENE	26	30·374	30·394	30·381	30·389	60·4	51·6	SW
27	30·398	30·416	30·364	30·386	65·6	40·1	NNE	27	30·385	30·394	30·394	30·422	63·1	52·8	WSW
28	30·375	30·393	30·352	30·352	58·1	47·4	N	28	30·444	30·467	30·431	30·435	61·3	49·1	N
29	30·272	30·211	30·120	30·094	55·3	46·2	NE	29	30·397	30·345	30·275	30·236	59·3	52·6	NW
30	30·001	29·950	29·859	29·849	56·2	47·4	NE	30	30·182	30·147	30·088	30·074	59·1	52·6	ENE

OCTOBER, 1902.

1	29·821	29·805	29·792	29·819	57·4	50·2	NE	1	30·063	30·100	30·108	30·148	54·4	49·5	E
2	29·846	29·959	30·021	30·081	53·0	42·8	NE	2	30 176	30·246	30·247	30·303	53·1	44·4	ENE
3	30·094	30·110	30·081	30·093	47·0	42·8	NE	3	30·315	30·307	30·255	30·277	49·5	41·9	E
4	30·074	30·081	30·024	30·008	47·6	43·7	NE	4	30·257	30 259	30·206	30·210	52·1	37·0	ESE
5	29·949	29·923	29·887	29·872	52·3	45·9	NE	5	30·161	30·151	30·102	30·100	53·1	45·2	ESE
6	29·814	29·796	29·780	29·792	51·4	46·6	N	6	30·028	29·980	29·921	29·915	50·6	45·4	E
7	29·767	29·790	29·789	29·832	56·0	45·0	NW	7	29·883	29·894	29·884	29 901	50·4	42·8	E
8	29·839	29·885	29·844	29 859	56·7	41·8	N	8	29·895	29·915	29·880	29·914	51·2	36·3	ESE
9	29·788	29·672	29·548	29·471	55·1	46·4	ENE	9	29·898	29·888	29·802	29·768	50·3	42·8	E
10	29·397	29·474	29·478	29·477	64·3	53·0	S	10	29·651	29·601	29·561	29·609	50·8	39·3	NE
11	29·457	29·536	29·662	29·842	58·7	50·2	N	11	29·639	29·719	29·765	29·881	52·4	37·1	WNW
12	30·005	30·180	30·238	30·280	58·1	46·0	N	12	29·949	30·015	29·953	29·846	55·0	34·9	S
13	30·218	30·181	30·108	30·011	61·0	49·7	SSW	13	29·892	29·946	29·859	29·807	54·8	46·9	WSW
14	29·832	29·880	29·880	29·919	59·2	48·6	W	14	29·680	29·655	29·613	29·559	54·3	48·3	W
15	29·816	29·656	29·492	29·450	59·0	48·7	SSW	15	29·186	28·929	28·773	28·683	54·1	48·0	SW
16	29·408	29·494	29·530	29·628	56·0	43·5	W	16	28·981	29·182	29·283	29·377	51·4	47·4	WNW
17	29·644	29·717	29·761	29·775	53·1	42·1	WNW	17	29·482	29·594	29·592	29·578	52·2	43·2	WNW
18	29·593	29·567	29·734	29·890	51·5	42·0	N	18	29·615	29·735	29·787	29·850	49·4	37·5	ENE
19	29·982	30·024	29·953	29·870	53·9	34·9	N	19	29 851	29·832	29·736	29·637	50·3	36·3	SW
20	29·823	29·721	29·719	29·783	60·1	45·9	SSW	20	29·530	29·559	29·605	29·654	51·9	43·9	W
21	29·894	30·030	30·085	30·142	55·9	41·5	W	21	29·691	29·774	29·810	29·768	49·8	41·5	WSW
22	30·065	29·994	30·112	30·287	55·0	41·1	WNW	22	29·636	29·950	30·070	30·118	52·9	43·3	W
23	30·367	30·451	30·454	30·507	54·1	40·5	W	23	30·130	30·176	30·187	30·196	55·8	49·2	SW
24	30·501	30·545	30·484	30·475	57·0	45·3	W	24	30·161	30·161	30·099	30 254	55·2	48·1	SW
25	30·445	30·455	30·393	30·345	59·8	45·9	W	25	30·312	30·339	30·226	30·079	52·0	39·2	E
26	30·225	30·114	29·976	30·007	55·9	44·3	SSW	26	29·749	29·538	29·808	29·984	56·0	46·5	NW
27	30·010	30·050	30·064	30·105	54·0	41·7	N	27	30·020	30·028	29·966	29·941	49·6	39·0	NNE
28	30·102	30·122	30·107	30·130	55·7	39·4	SW	28	29·881	29·932	29·933	29·933	54·9	46·3	WSW
29	30·101	30·108	30·043	30·061	54·7	41·9	S	29	29·855	29·831	29·814	29·831	56·3	50·3	WSW
30	30·025	30·050	30·064	30·150	55·6	40·5	WNW	30	29·856	29·938	30·018	30·079	51·1	42 8	WNW
31	30·170	30 210	30·156	30·122	51·9	36·0	WNW	31	30·008	29·896	29·851	29·859	55·0	41·1	WSW

NOVEMBER, 1902.

KEW.								GLASGOW.							
	Barometer.				Temperature.				Barometer.				Temperature.		
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon.
1	30·098	30·104	30·084	30·158	57·6	45·7	WSW	1	29·825	29·862	30·012	30·150	54·5	42·9	WNW
2	30·205	30·269	30·211	30·192	53·6	43·6	E	2	30·197	30·197	30·100	30·037	46·7	34·8	NNE
3	30·127	30·119	30·077	30·109	51·1	37·9	NNW	3	29·946	29·911	29·960	30·021	51·4	39·9	SW
4	30·085	30·069	29·945	29·862	52·3	41·0	ESE	4	29·995	29·993	29·913	29·864	52·1	43·7	E
5	29·733	29·659	29·560	29·612	56·0	43·9	E	5	29·757	29·971	29·503	29·431	51·6	47·8	ESE
6	29·640	29·604	29·463	29·369	58·1	50·7	E	6	29·416	29·475	29·452	29·351	56·2	49·3	SSE
7	29·339	29·536	29·613	29·674	58·2	48·0	SW	7	29·191	29·151	29·246	29·390	56·1	46·0	SE
8	29·651	29·486	29·421	29·474	53·7	44·9	SSE	8	29·360	29·215	28·926	28·910	49·1	43·2	ESE
9	29·473	29·541	29·590	29·752	53·5	45·4	SW	9	28·872	29·034	29·245	29·419	51·1	44·2	W
10	29·815	29·887	29·870	29·859	52·6	42·9	SW	10	29·500	29·609	29·637	29·648	50·1	43·2	SW
11	29·777	29·678	29·586	29·605	53·5	44·0	E	11	29·619	29·584	29·440	29·362	49·4	43·2	ESE
12	29·713	29·931	30·029	30·121	55·8	36·0	SW	12	29·439	29·537	29·701	29·756	50·2	45·2	SW
13	30·139	30·168	30·127	30·188	52·4	31·8	WSW	13	29·747	29·765	29·715	29·912	54·4	46·3	SW
14	30·229	30·318	30·314	30·360	53·8	35·6	SSW	14	30·087	30·217	30·208	30·194	49·7	41·5	NNE
15	30·321	30·347	30·252	30·227	48·5	42·3	E	15	30·198	30·233	30·209	30·185	53·7	45·4	ESE
16	30·220	30·248	30·237	30·274	44·5	39·8	E	16	30·157	30·216	30·250	30·285	49·9	43·1	ESE
17	30·279	30·297	30·285	30·306	43·2	36·3	ENE	17	30·291	30·326	30·323	30·349	46·3	36·1	ENE
18	30·294	30·290	30·213	30·177	40·1	34·0	ENE	18	30·356	30·388	30·366	30·374	43·6	35·8	ESE
19	30·119	30·086	30·037	30·094	34·8	32·9	NE	19	30·326	30·287	30·251	30·268	41·8	35·3	E
20	30·116	30·158	30·198	30·279	35·6	29·9	N	20	30·270	30·298	30·275	30·250	43·9	37·0	ESE
21	30·278	30·250	30·143	30·137	38·0	29·9	E	21	30·202	30·158	30·054	30·012	39·8	32·7	E
22	30·118	30·114	30·040	29·991	41·3	34·1	SSE	22	29·932	29·881	29·803	29·741	38·3	32·4	ENE
23	29·917	29·951	29·950	29·948	50·3	37·6	SW	23	29·693	29·723	29·703	29·721	46·3	36·1	WSW
24	29·856	29·694	29·446	29·357	51·6	34·9	SE	24	29·665	29·546	29·370	29·293	44·3	36·9	E
25	29·269	29·220	29·164	29·218	51·7	48·7	SE	25	29·250	29·284	29·297	29·325	49·1	43·6	ESE
26	29·281	29·366	29·408	29·506	50·6	47·3	E	26	29·330	29·378	29·420	29·475	47·9	45·1	ESE
27	29·556	29·619	29·596	29·530	48·1	42·0	N	27	29·475	29·465	29·389	29·265	47·9	43·9	S
28	29·357	29·219	29·207	29·341	49·6	40·2	SSW	28	29·097	29·051	28·974	28·995	47·5	40·9	E
29	29·339	29·364	29·383	29·396	50·0	39·0	SE	29	29·162	29·308	29·387	29·489	45·1	38·0	ENE
30	29·365	29·459	29·497	29·549	47·5	45·1	E	30	29·596	29·695	29·699	29·675	45·5	38·9	ESE

DECEMBER, 1902.

1	29·582	29·611	29·475	29·288	49·6	44·3	W	1	29·553	29·451	29·319	29·208	43·6	38·9	SE
2	29·291	29·519	29·629	29·690	49·7	37·8	NE	2	29·203	30·348	29·489	29·655	41·9	38·3	ENE
3	29·742	29·935	30·128	30·317	38·7	29·1	N	3	29·859	30·056	30·241	30·380	40·3	34·5	E
4	30·411	30·488	30·497	30·537	34·9	27·3	E	4	30·470	30·537	30·547	30·574	35·7	29·4	SE
5	30·489	30·449	30·382	30·352	33·0	25·9	ENE	5	30·540	30·525	30·496	30·419	34·5	29·8	ESE
6	30·322	30·316	30·325	30·325	33·0	25·7	E	6	30·400	30·386	30·347	30·369	35·1	25·5	SE
7	30·320	30·351	30·271	30·230	35·7	25·7	NE	7	30·363	30·391	30·371	30·370	29·6	24·2	ENE
8	30·184	30·148	30·067	30·057	35·7	33·2	NE	8	30·342	30·311	30·270	30·265	35·4	22·0	NNW
9	30·021	30·037	30·030	30·084	37·4	34·0	NE	9	30·257	30·287	30·307	30·351	32·8	24·5	E
10	30·086	30·109	30·098	30·166	38·7	35·1	ENE	10	30·375	30·410	30·388	30·349	39·3	36·1	ESE
11	30·152	30·194	30·138	30·124	36·7	33·8	ENE	11	30·265	30·240	30·161	30·109	39·8	35·2	ENE
12	30·077	30·075	30·017	29·997	44·2	32·4	E	12	30·044	29·980	29·901	29·810	36·8	34·1	ENE
13	29·994	30·043	30·063	30·152	49·5	44·4	S	13	29·980	29·936	29·952	29·773	47·3	34·1	SSW
14	30·210	30·212	30·128	30·004	52·1	44·1	SSW	14	29·785	29·511	29·450	29·429	52·7	41·5	SSW
15	29·884	29·911	30·100	30·227	50·7	38·3	WSW	15	29·362	29·481	29·845	29·792	46·1	38·3	WNW
16	30·111	29·920	29·838	29·865	55·7	40·6	SW	16	29·301	29·352	29·476	29·504	51·7	40·1	W
17	29·873	29·920	30·063	29·900	57·1	47·3	W	17	29·492	29·725	29·747	29·602	45·1	32·3	W
18	29·822	29·958	30·062	30·129	55·1	44·0	W	18	29·394	29·571	29·711	29·727	45·2	32·4	W
19	30·153	30·301	30·315	30·320	48·1	44·0	WNW	19	30·007	30·147	30·119	30·081	48·1	40·9	WSW
20	30·230	30·218	30·234	30·284	52·6	45·2	NNW	20	30·039	30·113	30·166	30·169	49·4	46·1	W
21	30·282	30·334	30·347	30·401	51·7	43·8	NW	21	30·210	30·283	30·319	30·350	51·0	46·8	W
22	30·437	30·503	30·499	30·527	49·3	46·2	NNW	22	30·367	30·396	30·381	30·383	47·1	42·3	WSW
23	30·513	30·580	30·542	30·534	46·3	39·3	WSW	23	30·354	30·392	30·334	30·327	46·0	41·8	SW
24	30·523	30·499	30·449	30·411	40·7	35·8	WSW	24	30·227	30·158	30·034	30·018	49·1	45·4	SW
25	30·324	30·246	30·193	30·054	50·9	37·2	W	25	29·918	29·748	29·534	29·732	50·2	44·4	WSW
26	30·094	30·161	30·139	30·143	51·5	46·1	W	26	29·846	29·840	29·732	29·726	51·8	29·9	W
27	30·144	30·177	30·090	29·932	51·2	47·4	W	27	29·821	29·772	29·562	29·624	51·0	47·3	WSW
28	29·722	29·691	29·592	29·371	49·3	41·7	W	28	29·166	29·056	28·955	28·858	48·1	32·5	WSW
29	29·291	29·103	29·008	28·932	44·0	35·4	SW	29	28·656	28·552	28·417	28·543	41·3	31·9	S
30	28·911	28·867	28·945	29·026	40·5	34·8	SW	30	28·626	28·767	29·024	29·067	41·1	37·9	WNW
31	29·081	29·206	29·337	29·474	42·0	32·9	WNW	31	29·107	29·225	29·306	29·368	41·3	22·3	NW

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AND.

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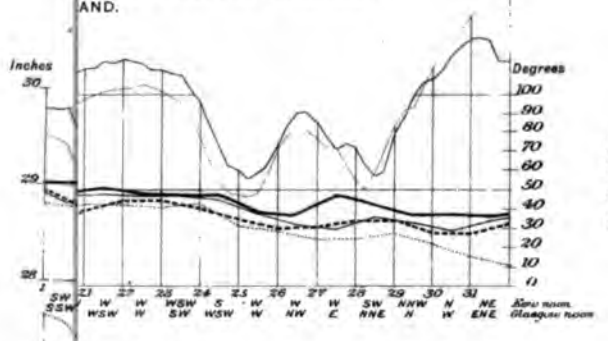

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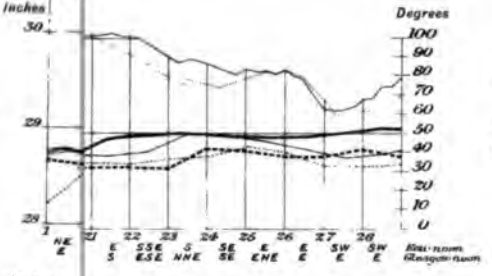

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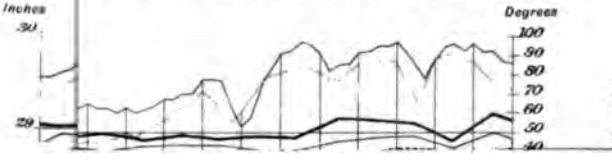

NOVEMBER, 1902.

KEW.								GLASGOW.							
	Barometer.				Tempera-ture.		Direction of wind at noon.		Barometer.				Tempera-ture.		Direction of wind at noon.
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.		Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	
1	30·098	30·104	30·084	30·158	57·6	45·7	WSW	1	29·825	29·862	30·012	30·150	54·5	42·9	WSW
2	30·205	30·269	30·211	30·192	53·6	43·6	E	2	30·197	30·197	30·100	30·037	46·7	34·5	NNE
3	30·127	30·119	30·077	30·109	51·1	37·9	NNW	3	29·946	29·911	29·960	30·021	51·4	39·9	SW
4	30·085	30·069	29·945	29·862	52·3	41·0	ESE	4	29·995	29·993	29·913	29·864	52·1	43·7	E
5	29·733	29·659	29·560	29·612	56·0	43·9	E	5	29·757	29·971	29·503	29·431	51·6	47·8	ESE
6	29·640	29·604	29·463	29·369	58·1	50·7	E	6	29·416	29·475	29·452	29·351	56·2	49·3	SSE
7	29·339	29·536	29·613	29·674	58·2	48·0	SW	7	29·191	29·151	29·246	29·390	56·1	46·0	SE
8	29·651	29·486	29·421	29·474	53·7	44·9	SSE	8	29·360	29·215	28·926	28·910	49·1	43·2	ESE
9	29·473	29·541	29·590	29·752	53·5	45·4	SW	9	28·872	29·034	29·245	29·419	51·1	44·2	W
10	29·815	29·887	29·870	29·859	52·6	42·9	SW	10	29·500	29·609	29·637	29·648	50·1	43·2	SW
11	29·777	29·678	29·586	29·605	53·5	44·0	E	11	29·619	29·584	29·440	29·362	49·4	43·2	ESE
12	29·713	29·931	30·029	30·121	55·8	36·0	SW	12	29·439	29·537	29·701	29·756	50·2	45·2	SW
13	30·139	30·168	30·127	30·188	52·4	31·8	WSW	13	29·747	29·765	29·715	29·912	54·4	46·3	SW
14	30·229	30·318	30·314	30·360	53·8	35·6	SSW	14	30·087	30·217	30·208	30·194	49·7	41·5	NNE
15	30·321	30·347	30·252	30·227	48·5	42·3	E	15	30·198	30·233	30·209	30·185	53·7	45·4	ESE
16	30·220	30·248	30·237	30·274	44·5	39·8	E	16	30·157	30·216	30·250	30·285	49·9	43·1	ESE
17	30·279	30·297	30·285	30·306	43·2	36·3	ENE	17	30·291	30·326	30·323	30·349	46·3	38·1	ENE
18	30·294	30·290	30·213	30·177	40·1	34·0	ENE	18	30·356	30·388	30·366	30·374	43·6	35·8	ENE
19	30·119	30·088	30·037	30·094	34·8	32·9	NE	19	30·326	30·287	30·251	30·268	41·8	35·3	E
20	30·116	30·158	30·198	30·279	35·6	29·9	N	20	30·270	30·298	30·275	30·250	43·9	37·0	ESE
21	30·278	30·250	30·143	30·137	38·0	29·9	E	21	30·202	30·158	30·054	30·012	39·8	32·7	E
22	30·118	30·114	30·040	29·991	41·3	34·1	SSE	22	29·932	29·881	29·803	29·741	38·3	32·4	ENE
23	29·917	29·951	29·950	29·948	50·3	37·6	SW	23	29·693	29·723	29·703	29·721	46·3	36·1	WSW
24	29·856	29·694	29·446	29·357	·6	34·9	SE	24	29·665	29·546	29·370	29·293	44·3	36·9	E
25	29·269	29·220	29·164	29·218	51·7	48·7	SE	25	29·250	29·284	29·207	29·325	49·1	43·6	ESE
26	29·281	29·366	29·408	29·506	50·6	47·3	E	26	29·330	29·378	29·420	29·475	47·9	45·1	ESE
27	29·556	29·619	29·596	29·530	48·1	42·0	N	27	29·475	29·465	29·389	29·265	47·9	43·9	S
28	29·357	29·219	29·207	29·341	49·6	40·2	SSW	28	29·097	29·051	28·974	28·995	47·5	40·9	E
29	29·339	29·364	29·383	29·396	50·0	39·0	SE	29	29·162	29·308	29·387	29·489	45·1	38·0	ENE
30	29·365	29·459	29·497	29·549	47·5	45·1	E	30	29·596	29·695	29·699	29·675	45·5	38·9	ESE

DECEMBER, 1902.

1	29·582	29·611	29·475	29·288	49·6	44·3	W	1	29·553	29·451	29·319	29·208	43·6	38·9	SE
2	29·291	29·519	29·629	29·690	49·7	37·8	NE	2	29·203	30·348	29·489	29·655	41·9	38·3	ENE
3	29·742	29·935	30·128	30·317	38·7	29·1	N	3	29·859	30·056	30·241	30·390	40·3	34·5	E
4	30·411	30·488	30·497	30·537	34·9	27·3	E	4	30·470	30·547	30·547	30·574	35·7	29·4	SE
5	30·489	30·449	30·382	30·352	33·0	25·9	ENE	5	30·540	30·525	30·456	30·416	34·5	29·8	ESE
6	30·322	30·316	30·325	30·325	33·0	25·7	E	6	30·400	30·386	30·347	30·360	35·1	27·5	SE
7	30·320	30·351	30·271	30·290	35·7	25·7	NE	7	30·363	30·391	30·371	30·370	29·6	24·2	ENE
8	30·184	30·148	30·067	30·057	35·7	33·2	NE	8	30·342	30·311	30·270	30·265	35·4	22·0	NNW
9	30·021	30·037	30·020	30·083	37·4	34·0	NE	9	30·257	30·287	30·307	30·351	30·8	34·5	E
10	30·086	30·109	30·098	30·166	38·7	35·1	ENE	10	30·375	30·410	30·388	30·349	39·3	36·3	ESE
11	30·152	30·194	30·138	30·124	36·7	33·8	ENE	11	30·268	30·240	30·161	30·109	39·8	35·2	ENE
12	30·077	30·075	30·017	29·997	44·2	32·4	E	12	30·044	29·980	29·901	29·810	36·8	34·1	ENE
13	29·994	30·043	30·063	30·152	49·5	44·4	S	13	29·980	29·936	29·852	29·773	47·3	34·1	SSW
14	30·210	30·212	30·128	30·004	52·1	44·1	SSW	14	29·785	29·511	29·450	29·422	52·7	41·5	SSW
15	29·884	29·911	30·100	30·227	50·7	38·3	WSW	15	29·562	29·481	29·865	29·792	46·1	38·3	WNW
16	30·111	29·920	29·838	29·865	55·7	40·6	SW	16	29·301	29·352	29·476	29·504	51·7	45·1	W
17	29·873	29·929	30·063	29·980	57·1	47·3	W	17	29·492	29·728	29·787	29·682	45·1	39·3	W
18	29·822	29·938	30·062	30·129	55·1	44·0	W	18	29·394	29·571	29·711	29·827	45·2	39·4	W
19	30·153	30·301	30·315	30·320	48·1	44·0	WNW	19	30·007	30·147	30·119	30·084	48·1	44·9	WSW
20	30·230	30·218	30·234	30·284	52·6	45·2	NNW	20	30·039	30·113	30·166	30·162	49·4	46·3	W
21	30·282	30·334	30·347	30·401	51·7	47·8	NW	21	30·210	30·285	30·319	30·350	51·0	46·8	W
22	30·437	30·503	30·499	30·527	49·3	46·2	NNW	22	30·367	30·386	30·381	30·383	47·1	42·3	WSW
23	30·533	30·580	30·542	30·534	46·3	39·3	WSW	23	30·374	30·392	30·334	30·327	46·0	41·8	SW
24	30·523	30·499	30·449	30·411	40·7	35·8	WSW	24	30·227	30·158	30·034	30·018	49·1	45·4	SW
25	30·324	30·246	30·193	30·053	50·9	37·2	W	25	29·918	29·748	29·534	29·792	50·2	44·4	WSW
26	30·094	30·161	30·139	30·143	51·5	46·1	W	26	29·846	29·911	29·732	29·726	51·8	39·9	W
27	30·144	30·177	30·099	29·932	51·2	47·4	W	27	29·821	29·774	29·562	29·784	51·0	47·3	WSW
28	29·722	29·691	29·592	29·371	49·3	41·7	W	28	29·166	29·056	28·955	28·858	48·1	42·5	WSW
29	29·201	29·103	29·048	28·932	44·0	35·4	SW	29	28·656	28·552	28·417	28·543	41·3	37·9	S
30	28·911	28·967	28·945	29·026	40·5	34·8	SW	30	28·626	28·707	28·824	29·067	41·1	37·9	WNW
31	29·081	29·206	29·357	29·474	42·0	32·9	WNW	31	29·107	29·225	29·306	29·368	41·3	32·5	NW

IMA TEMPERATURES AND THE DIRECTION
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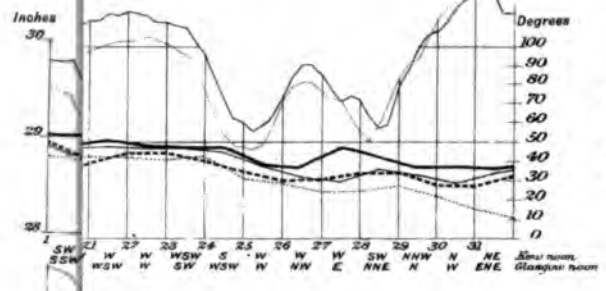
JANUARY.



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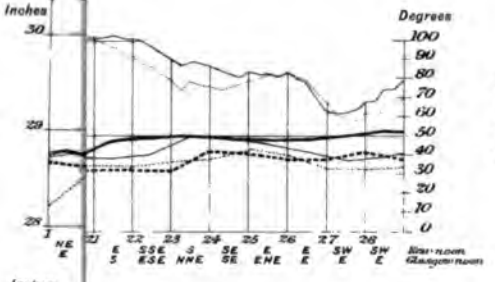

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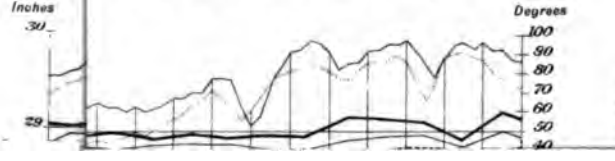

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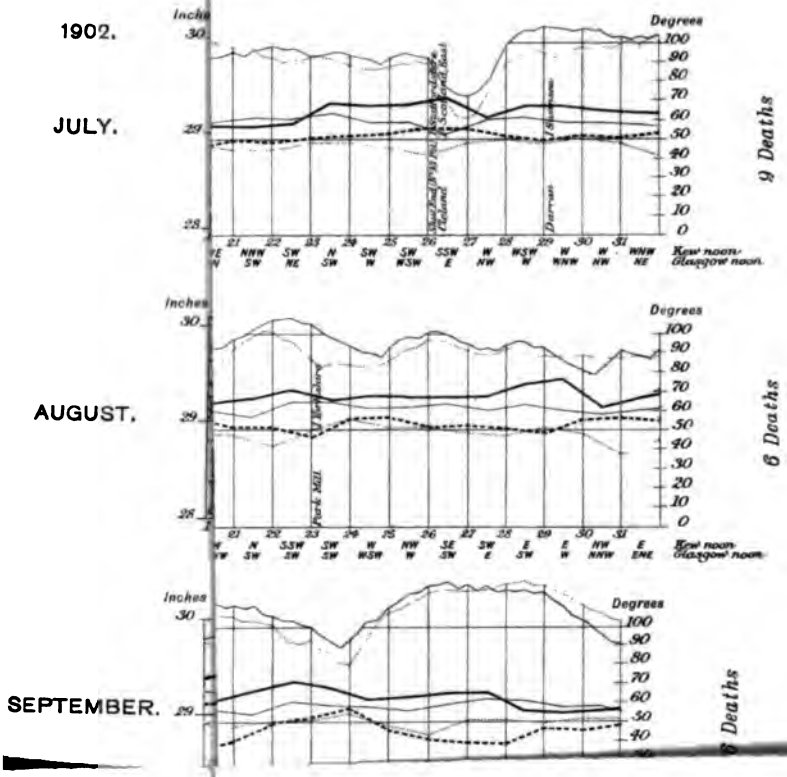

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